

POST-CONSTRUCTION OPERATIONAL NOISE ASSESSMENT
FOR THE PACIFIC HIGHWAY UPGRADE
BRUNSWICK HEADS TO YELGUN

TB586-06F02 (REV 1 - MAY 2008) POST CONSTRUCTION OPERATIONAL NOISE ASSESSMENT

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Prepared for:

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1 INTRODUCTION

Renzo Tonin & Associates (NSW) Pty Ltd has been engaged by AbiGroup to monitor and assess road traffic noise at dwellings along the alignment of the Pacific Highway Upgrade, Brunswick Heads to Yelgun, NSW (the Project).

The primary purpose of carrying out a post-construction operational noise assessment of the Brunswick Heads to Yelgun Pacific Highway Upgrade is that there is an environmental commitment under the Minister's Condition of Approval No. 34 to assess the adequacy of the noise mitigation measures.

The purpose of this report is to:

1. outline the objectives of the post-construction operational traffic noise monitoring program
2. describe the methodology of the post-construction operational traffic noise monitoring and assessment study
3. compare monitored noise levels to modelled noise levels
4. assess the accuracy of the noise modelling undertaken during the design stage
5. assess the adequacy of the implemented traffic noise mitigation measures
6. address community complaints regarding noise
7. assess noise predictions against the project's environmental noise criteria as outlined in previous environmental documents
8. present the results, findings and conclusions of the post-construction operational traffic noise assessment

In preparing this report, reference has been made to the following documents:

- Minister's Condition of Approval No. 27 for the Duplication of Brunswick Heads Bypass and Upgrade of Pacific Highway Between Brunswick River and Yelgun, August 1999 – Requirements for the preparation of an Operation Noise Management Report (ONMR)
- Minister's Condition of Approval No. 34 for the Duplication of Brunswick Heads Bypass and Upgrade of Pacific Highway Between Brunswick River and Yelgun, August 1999 – Requirements for operational noise monitoring
- Renzo Tonin & Associate's 'Operational Noise Management Report' (ONMR)
- NSW Government 'Environmental Criteria for Road Traffic Noise' (ECRTN) Policy
- NSW RTA's 'Environmental Noise Management Manual' (ENMM)
- Proposed Duplication of the Brunswick Heads Bypass and Upgrade of the Pacific Highway, Brunswick River to Yelgun Environmental Impact Statement – Summary and Main Volume, SKM, July 1998 (EIS)

- Proposed Duplication of the Brunswick Heads Bypass and Upgrade of the Pacific Highway, Brunswick River to Yelgun - Working Paper No 3 Noise Impact Assessment, Wilkinson Murray Pty Limited, June 1998 (EIS)
- Duplication of the Brunswick Heads Bypass and Upgrade of the Pacific Highway, Brunswick River to Yelgun Representations Report, RTA, February 1999 (RR)
- Pacific Highway Brunswick Heads to Yelgun, Modified Alternative Design Environmental Impact Assessment, Connell Wagner Pty Ltd November 2002 (EIA)
- Brunswick Heads to Yelgun Upgrade – Modification to Approved Project Submissions Report, RTA, April 2003 (SR)
- Brunswick Heads to Yelgun Upgrade. Modified Proposal (Modification to Approved Project). SH10 – Pacific Highway within Byron Shire Council Area. Environmental Impact Assessment Decision Report, RTA, May 2003 (DR)
- Combined Heavy Vehicle/ Light Vehicle Rest Area at Yelgun – Review of Environmental Factors, Acacia Environmental Planning Pty Ltd November 2004 (YRA)
- Combined Heavy Vehicle/Light Vehicle Rest Area at Yelgun, REF Decision Report, Feb 2005
- Proposed Change to the Access from the existing Pacific Highway and the Yelgun Interchange EIA, Acacia Environmental, June 2005
- Proposed Change to the Connection between the Yelgun Interchange and the Pacific Highway EIA, Decision Report, July 2005
- Proposed Change to the Access from the existing Pacific Highway and the Yelgun Interchange EIA, Decision Report, July 2005
- Brunswick Heads to Yelgun Scope of Work and Technical Criteria - Appendix 4: Additional Environmental Requirements
- Brunswick Heads to Yelgun Scope of Work and Technical Criteria - Appendix 20: Design Information

2 OBJECTIVES OF POST-CONSTRUCTION NOISE MONITORING PROGRAM

2.1 Background

The environmental requirements for the acoustical design of a large, high speed roadway like the Brunswick Heads to Yelgun Pacific Highway Upgrade need to be comprehensive in order to address the potential environmental noise effects of sensitive noise receivers potentially affected by traffic noise from the roadway. These requirements were implemented during the design and construction phase of the Project. They were documented in the Operational Noise Management Report (ONMR) and all the Project noise objectives, procedures and design outcomes are not repeated in this report. However, a summary of these and some further discussion is provided in Chapter 4.

The proposed management measures and design criteria outlined in the ONMR address the requirements of Condition 27 of the Minister's Conditions of Approval (MCoA), the NSW Environmental Criteria for Road Traffic Noise (ECRTN) (EPA, 1999), the Roads and Traffic Authority's Environmental Noise Management Manual (ENMM) (RTA, 2001) and Appendices 4 and 20 of the Scope of Work and Technical Criteria (SWTC). Therefore, given that the design process and the ONMR assessed noise at properties in terms of the environmental criteria applicable to the project, a key purpose of the post-construction noise assessment is to evaluate the accuracy of the modelling undertaken at the design stage.

The primary purpose of the post-construction operational traffic noise compliance investigations and any supplementary actions carried out in response to the findings of those investigations are:

- conduct measurements of actual traffic noise levels at dwellings post-opening to determine whether the intended acoustical outcomes as described in the environmental documents and the ONMR were actually achieved,
- if there is a clear trend in traffic noise levels which are higher than the predictions made and exceed the noise goals, determine whether additional noise mitigation measures are required, and
- address community noise complaints by re-assessing traffic noise levels at the complainant properties or properties in the vicinity of where complaints have arisen and assess noise levels against the applicable environmental noise criteria at these representative locations.

2.2 Actions

The following outlines the actions of the post-construction operational noise assessment of the Brunswick Heads to Yelgun Pacific Highway Upgrade:

- Measure actual traffic noise and traffic volumes after the opening of the road upgrade.
- Use measured actual traffic noise and volume data to validate the noise prediction model implemented during the design and construction stage of the project.
- Where the noise prediction model and input data are found to validate correctly, then previous predicted noise levels presented in the ONMR are considered to be correct and noise mitigation measures presented in the ONMR are applicable.
- Where the validation process indicates differences then validation corrections are applied to the noise prediction model and future traffic noise levels (10 years after opening) are predicted with the corrected model.
- Compare measured 2007 traffic data obtained as part of the post-construction noise monitoring to the traffic data presented in the SWTC for the year 2006. Should traffic data results for 2007 be less than the 2006 traffic data in the SWTC, then the traffic data provided in the SWTC for the 2016 design year would be considered conservative and would be applicable in the post-construction noise assessment.
- Should the measured 2007 traffic data be greater than the 2006 traffic data of the SWTC, then 2017 traffic data would be re-forecast by the RTA, and the re-forecast 2017 traffic data would be used in the post-construction noise assessment.
- 2017 traffic noise levels would be compared to the 2016 traffic noise levels predicted during the design phase, and compared against the environmental noise criteria established for the project as set out in the EIA to determine the adequacy of the noise mitigation measures implemented.

Furthermore, following the completion of the above process additional mitigation measures to those already implemented to date would, according to MCoA No.34, be considered *'should the assessment indicate a clear trend in traffic noise levels which are higher than the predictions made and exceed the EPA noise goals'*. That is, additional noise mitigation measures would only be considered should there be a 'clear trend' of shortfalls between 'measured outcomes' and 'predicted outcomes'.

In addition to the above actions, noise monitoring of maximum noise levels with the potential to cause sleep disturbance have been conducted. However, the monitored maximum noise levels are not used to determine the adequacy of mitigation measures presented in the ONMR, but instead the monitored results are to provide a comparison of the maximum noise levels before the Upgrade and after the Upgrade.

3 ENVIRONMENTAL OBLIGATIONS

3.1 Ministers Conditions of Approval

As part of the Ministers Conditions of Approval (MCoA) relating to the operation of the Brunswick Heads to Yelgun Pacific Highway Upgrade, post-construction operational noise monitoring is required to be undertaken. Table 1 summarises all of the MCoAs relevant to operational noise.

Table 1 – Conditions of Approval

MCoA No.	MCoA (summary)	Addressing of MCoA
26	<p>A detailed Noise and Vibration Management Sub-plan shall be prepared as part of the EMP (Construction Stage) to the satisfaction of the EPA. The Sub-plan shall provide details of noise and vibration control measures to be undertaken during the construction stage, sufficient to address the technical requirements for any EPA approvals/licenses. The Sub-plan shall include, but not limited to:</p> <ul style="list-style-type: none"> I) Tests for ascertaining acoustic parameters; II) Identification of noise and vibration catchments and predicted noise and vibration levels; III) Impacts from site compounds/construction depots; IV) Location, type and timing of erection of temporary and permanent noise barriers and/or other noise mitigation measures; V) Specific physical and managerial measures for controlling noise and vibration; VI) Noise and vibration monitoring, reporting and response procedures; and VII) The urban design issues relating to noise and vibration control measures. <p>With respect to sub-clause (iv), the Proponent shall consider the use of a range of structural and non-structural noise mitigation measures including barriers, acoustic treatment of residences, scheduling of construction activities and temporary relocation of affected residents.</p>	<p>The Noise, Vibration and Air blast Management Plan; vibration survey reports; technical reports; and technical memos submitted to DoP, DECC and RTA address the construction noise and vibration requirements of this MCoA.</p>
27	<p>The Proponent must prepare an Operation Noise Management Report detailing its investigation of reasonable and feasible operation noise mitigation methods. The Proponent must obtain the approval of the Director-General for the Report prior to construction commencing or within any other time agreed to by the Director-General. The report and investigation must be conducted in accordance with the NSW Government's Environmental Criteria for Road Traffic Noise and the RTA's Environmental Noise Management Manual. The report and investigation must include:</p> <ul style="list-style-type: none"> a) Identification of operation noise criteria; b) Predictions of noise levels at noise sensitive locations; c) The location, type and timing of erection of permanent noise barriers and/or other noise mitigation measures (including road surface) demonstrating best practice; d) Details of specific physical and managerial measures for controlling noise; e) Details of reasonable and feasible noise mitigation measures. To assist in selecting noise mitigation options for road traffic noise an analysis for the entire Project must be undertaken in accordance with Practice Note IV of the RTA Environmental Noise Management Manual. The importance applied to aesthetic impacts (visual, shadowing etc.) and noise mitigation along the Project must be determined in consultation with the CLG and owners of noise affected, noise sensitive land uses. Among other options 	<p>The ONMR submitted to DoP, DECC and RTA addresses the operational traffic noise requirements of this MCoA. The ONMR was approved by DoP on 29 June 2007.</p>

MCoA No.	MCoA (summary)	Addressing of MCoA
	<p>consideration should be given to the inclusion of clear panels within noise barriers to reduce visual and overshadowing impacts;</p> <p>f) The urban design issues relating to noise control measures;</p> <p>g) Details of noise monitoring, reporting and complaint response procedures; and</p> <p>h) Consideration of noise mitigation for sensitive receptors predicted to have "future existing" noise levels in the year 2016 at an acute level or above. Acute noise levels are 65 dB(A) $L_{eq(15hr)}$ (day) and 60 dB(A) $L_{eq(9hr)}$ (night).</p> <p>The Proponent must install all reasonable and feasible noise mitigation measures identified in the Operation Noise Management Report to the satisfaction of the Director-General.</p>	
34	<p>Monitoring of the noise when operational shall be undertaken as part of the Noise and Vibration Management Sub-plan. The Proponent shall, in consultation with EPA, assess the adequacy of the traffic noise mitigation measures. Should the assessment indicate a clear trend in traffic noise levels which are higher than the predictions made and exceed the EPA noise goals, the measures such as consideration of open grade asphalt road pavement, inclusion and/or heightening of noise barriers, insulation of buildings, partial or total acquisition of properties or any other measure as agreed to by the EPA.</p> <p>Notwithstanding the above, the Proponent shall ensure compliance with the noise assessment criteria as described in the EIS unless otherwise approved by the EPA.</p>	<p>This post-construction operational noise assessment addresses this MCoA.</p>

3.2 SWTC – Appendix 4

The Project's 'Scope of Work and Technical Criteria' (SWTC), Appendix 4 states the following:

Table 2 – Scope of Work and Technical Criteria – Appendix 4 Noise Requirements

Clause No.	Appendix 4 – Noise Requirements	Addressing of Clause
4.20	<p>Operation Noise Management Report</p> <p>In addition to the requirements of other Environmental Documents the Contractor must prepare an operation noise management report which must include a noise study of the Contractor's design. The noise study must use the input variables of traffic speeds, volume, composition and growth identified in Appendix 20.</p> <p>In addition to the requirements of the other Environmental Documents the operation noise management report must contain the following details in relation to the study:</p> <p>a) A brief description of the prevailing ambient noise environment;</p> <p>b) Documentation of the location of noise monitors, including an indication of the distance to the nearest road, where a road is located close to the noise monitors;</p> <p>c) A site plan showing the locations of noise monitoring;</p> <p>d) Aerial photographs showing the locations of the noise monitoring;</p> <p>e) Location details of any noise loggers, including site photographs identifying the noise loggers;</p> <p>f) Using 15-minute intervals, charts of noise parameters, including the LAmax, LA10, LAeq and LA90, for each 24-hour period of the monitoring survey;</p> <p>g) A table summarising the noise parameters measured;</p>	<p>The ONMR submitted to DoP, DECC and the RTA address these requirements. The ONMR was approved by DoP on 29 June 2007.</p>

Clause No.	Appendix 4 – Noise Requirements	Addressing of Clause
	h) Tabulations of Average Annual Daily Traffic (AADT) predictions for the day and night periods;	
	i) Summaries of the computational algorithms used and justification for their selection, the location of noise-sensitive dwellings and how the modelling parameters were addressed;	
	j) A table summarising the relevant noise parameters computed at the monitoring locations and comparing them with the design noise objectives;	
	k) Sensitivity and statistical analysis of key data in order to estimate confidence interval and reliability;	
	l) Well presented noise contour maps for the LAeq (15 hour) Day, LAeq (9 hour) Night for 2006 and 2016 noise environment identifying all noise-sensitive locations in the study area. The contour maps must be presented for intervals of not greater than 5 dB(A) and extend to 45dB(A);	
	m) Assessment of maximum noise levels to evaluate sleep disturbance impacts and determination of mitigation options;	
	n) Identification of resident locations that are predicted to exceed the ECRTN (base criteria and allowance criteria) 10 years after opening and at road noise mitigation measures to be implemented to meet the ECRTN;	
	o) Identification of all operational noise treatments to maintain noise levels at or below the contour lines identified in Figures 20.9 and 20.10 in Appendix 20 to this Scope of Works and Technical Criteria;	
	p) Consideration of construction and operational noise on passive recreational areas, including Brunswick Heads Nature Reserve in accordance with ECRTN. Brunswick Heads Nature Reserve is classed as a Category 5 Sensitive Land Use. The report must identify construction and operational noise levels at agreed monitoring sites within the Brunswick Heads Nature Reserve and detail noise mitigation measures required to ensure compliance with the ECRTN requirements. Existing noise levels must be measured at one or more locations, to be agreed with the DEC and RTA's Representative, within the Brunswick Heads Nature Reserve.	

Clause No.	Appendix 4 – Noise Requirements	Addressing of Clause
4.21	<p>Noise Mitigation</p> <p>a) Further to the requirements of 27(e) of the MIP Approval, RTA have consulted with the owners of noise affected and noise sensitive land uses and determined, in consultation with the owners, the scope and extent of noise mitigation and treatments to be applied to residences. The noise mitigation and treatments will be undertaken by RTA and the Contractor must not undertake any at-residence treatments to address the operational noise mitigation requirements of the Environmental Documents. The Contractor must comply with the operational noise mitigation requirements of the Environmental Documents using noise mitigation and treatments other than at-residence treatments. In addition, noise mitigation is not required at commercial or industrial premises in accordance with Practice Note ii of RTA Environmental Noise Management Manual, December 2001.</p> <p>b) Further to any other requirements of the Environmental Documents in relation to noise mitigation measures, the Contractor must design and provide operational noise mitigation and treatments:</p> <ul style="list-style-type: none"> (i) so as not to be constrained by any financial, costing, feasibility or other constraints on types of mitigation identified in the Environmental Noise Management Manual (RTA December 2001); and (ii) so that operational noise levels are maintained at or below the levels indicated by the contour lines in Figures 20.9 and 20.190 of Appendix 20 to this Scope of Works and Technical Criteria. <p>(c) The pavement wearing surface must be designed to produce noise levels and tonal characteristics that contribute to the provision of noise levels that satisfy the requirements of the Deed. The Upgrade between Point 'C' of Figure 1.3 of Appendix 1 to this Scope of Works and Technical Criteria and the northern limit of the Project Site must be treated as a noise sensitive area. Pavement wearing surfaces within the noise sensitive area must comply with section 7.14.3 of the Scope of Works and Technical Criteria.</p> <p>(d) Bridge joints must be designed and selected and installed to reduce vehicle noise impacts.</p> <p>(e) At-road noise mitigation measures, including noise walls, "Tall Walls" and Type "F" barriers, must be provided, as a minimum, at the locations and with the lengths and heights required by section 20.3.4 of Appendix 20 to this Scope of Works and Technical Criteria.</p>	<p>The ONMR submitted to DoP, DECC and the RTA address these requirements. The ONMR was approved by DoP on 29 June 2007.</p>

4 PROJECT NOISE LEVELS OBJECTIVES

In determining the traffic noise level criteria that apply to the Brunswick Heads to Yelgun Pacific Highway Upgrade, reference was made to the environmental documents prepared for this Project, namely the EIS (1998) and the EIA (2002).

Also in accordance with MCoA No.27 reference was made during the design stage to the NSW 'Environmental Criteria for Road Traffic Noise' (ECRTN) and the RTA's 'Environmental Noise Management Manual' (ENMM).

The noise level objectives for the Project are detailed in the Operational Noise Management Report (ONMR) [ref: TB586-03F02 (rev 16), dated 2 April 2007], however a summary is presented below.

4.1 Residential Noise Receptors

According to the ECRTN and ENMM, this Project has two (2) noise criteria categories with respect to Table 1 of the ECRTN:

- **Category 1** – New Freeway or Arterial Road Corridor: areas not currently exposed to road traffic noise.
- **Category 3** – Redevelopment of Existing Freeway / Arterial Road: areas currently exposed to road traffic noise.

The relevant noise criteria for this Project are presented in Table 3 below.

Table 3 – NSW Environmental Criteria for Road Traffic Noise

Category / Type of Development	Criteria		Where Criteria are Already Exceeded
	Day, dB(A)	Night, dB(A)	
1. New freeway or arterial road corridor	$L_{Aeq(15hr)}$ 55	$L_{Aeq(9hr)}$ 50	The new road should be designed so as not to increase existing noise levels by more than 0.5 dB(A). Where feasible and reasonable, noise levels from existing roads should be reduced to meet the noise criteria. In some instances this may be achievable only through long-term strategies such as improved planning, design and construction of adjoining land use developments; reduced vehicle emission levels through new vehicle standards and regulation of in-service vehicle; greater use of public transport; and alternative methods of freight haulage.

Category / Type of Development	Criteria		
	Day, dB(A)	Night, dB(A)	Where Criteria are Already Exceeded
3. Redevelopment of existing freeway/arterial road	$L_{Aeq(15hr)} 60$	$L_{Aeq(9hr)} 55$	In all cases, the redevelopment should be designed so as not to increase existing noise levels by more than 2 dB(A). Where feasible and reasonable, noise levels from existing roads should be reduced to meet the noise criteria. In many instances this may be achievable only through long-term strategies such as improved planning, design and construction of adjoining land use developments; reduced vehicle emission levels through new vehicle standards and regulations of in-service vehicles; greater use of public transport; and alternative methods of freight haulage.

Source: 'Environmental Criteria for Road Traffic Noise' (May 1999).

In addition to the above, where the predicted design year noise levels at residences exceed 65dB(A) Day and 60dB(A) Night as a result of the Project, then the noise exposure is considered to be 'acute' and noise control measures were considered.

'Feasibility' relates to engineering considerations and what can practically be built. 'Reasonableness' is judged in terms of noise mitigation benefits and costs, and many other aspects such as community views, aesthetic impacts, existing and future noise levels at the affected sites and the benefits arising from the development.

To establish the most reasonable and feasible noise mitigation treatment in areas affected by significant traffic noise levels, reference is made to Practice Note IV of the RTA's 'Environmental Noise Management Manual' (ENMM).

4.2 Non-Residential Land Use Developments

The ECRTN also sets guidelines for the assessment of traffic noise on sensitive land use developments.

Table 4 – NSW Environmental Road Traffic Noise Criteria for Sensitive Land Use Developments

Type of Development	Noise Criteria, dB(A)		Noise Mitigation Measures
	Day	Night	
Places of worship	$L_{eq(1hr)} = 40$ ¹	$L_{eq(1hr)} = 40$ ¹	To achieve internal noise criteria in the short-term, the most practicable mitigation measures are often related to building or facade treatments. In the medium to longer term, strategies such as regulation of exhaust noise from in-service vehicles, limitations on exhaust brake use, and restricting access for sensitive areas or during sensitive times to low noise vehicles can be applied to mitigate noise impacts across the road system.
Active recreation (eg golf courses)	$L_{eq(15hr)} = 60$ ²	-	Other measures include improved planning, design and construction of sensitive land use developments; reduced new vehicle emission standards; greater use of public transport; and alternative methods of freight haulage. These medium to long-term strategies apply equally to mitigating internal and external noise levels.

Type of Development	Noise Criteria, dB(A)		Noise Mitigation Measures
	Day	Night	
Passive recreation and school playgrounds	$L_{eq(15hr)} = 55^2$	-	Where existing levels of traffic noise exceed the criteria, all feasible and reasonable noise control measures should be evaluated and applied. Where this has been done and the internal or external criteria (as appropriate) cannot be achieved, the proposed road or land use development should be designed so as not to increase existing road traffic noise levels by more than 0.5dB(A) for new roads and 2dB(A) for redeveloped roads or land use development with potential to create additional traffic.

Source: 'Environmental Criteria for Road Traffic Noise' (May 1999).

Note: 1. Internal noise criteria

2. External noise criteria

In accordance with Appendix 4, Clause 4.20, Part (p) of the SWTC, Category 5 – 'Passive recreation and school playgrounds' is applicable for the Brunswick Heads Nature Reserve. Furthermore, the Christian Life Centre in Billinudgel and the Ocean Shores Golf Course are assessed as 'Places of worship' and 'Active recreation' sensitive land uses, respectively.

4.3 Project Specific Noise Criteria

The applicable noise criteria for this Project was determined in the EIA (2002) as outlined below. Table 5 provides a summary of the appropriate criterion for the assessed residences within each NCA. This table, extracted from the EIA (Appendix E Table 4.1), summarises the applicable traffic noise criteria used in the EIA. The governing criteria in all cases is the $L_{Aeq,9hr}$.

Table 5 – Operational Noise Criteria for Noise Sensitive Receptors

NCA	Location	EIA Noise Criteria, $L_{eq(9h)}$ dB(A)
1	Lot 264 Bayside Way	55
1	2 Cudgen St	55
2	Bashforths-Bashforth Ln	55
3	Ferry Reserve CP (Amenity Building)	65
3	Ferry Reserve CP (Campsite)	63
3	Riverside Crescent	55
4	2 Rajah Road	60.5
4	2 Rajah Road (top floor)	60.5
4	1 Rajah Road	61
4	2 Arika Avenue	61
4	2 Arika Ave (top floor)	63
4	5 Arika Avenue	64
5	1 Oola Place	62.5
5	Oba Place	64.5
5	Weeronga Wy (west)	64.5

NCA	Location	EIA Noise Criteria, $L_{eq(9h)}$ dB(A)
6	5 Weeronga Wy (east)	55
7	Tongarra Drive	67
8	Binya Place	50
9	Mountain View Rd	55
9	Coolamon Scenic Dr	56
10	Yamble Drive (Sth)	70.5
10	48 Yamble Drive	60.5
11	Balemo Drive (Sth)	60.5
12	Lot 6, The Tunnel Rd	50
12	Villa Ruidosa Cottage	50
13	1 Kulgun Ct	61
14	Ulpira/Nargoon	60.5
15	Matong Drive	64.5
16	Humble Pie Company	N/A
16	Christian Life Centre ¹	69.5
16	Funeral Parlour	64
16	Lot 1 Pacific Highway	59
17	21 Gilba Avenue	59
18	123 Balemo Drive	60.5
19	175 Billinudgel Road	58.5
19	Holm res. Billinudgel Rd	50
20	Holm farm Billinudgel Rd	50
21	"Jagwen" Pacific Highway	51

Note: 1. Noise levels are $L_{Aeq(1hr)}$

4.4 Discussion of Operational Traffic Noise Assessment

The ONMR was issued to the relevant regulatory authorities including the Roads and Traffic Authority (RTA) and the Department of Planning (DoP). The ONMR was also reviewed by the Independent Verifier (IV) and the Environmental Management Representative (EMR). Comments received were incorporated into the ONMR. Approval by the DoP was received on 29 June 2007.

The approach followed during the design stage of the Project is in line with the ECRTN which states:

- *"The framework embodies a non-mandatory performance-based approach."* (p. 2)
- *"The non-mandatory nature of the criteria implies a process that needs to be followed to derive achievable noise levels for specific projects. That process commences with the criteria providing the target level that should be sought to be met and then incorporates considerations of cost, feasibility, equity and community preferences."*

Where it can be demonstrated that the target is not practicable, feasible or reasonable to achieve within the project planning, design and implementation for justifiable reasons, then the criteria should be approached as closely as possible, with the aim of adopting broader supporting strategies for achieving the criteria in the longer term.

In this context, feasibility relates to engineering considerations and what can be practically be built.

Reasonableness relates to the application of judgement, taking into account the following factors:

- *Noise mitigation benefits - amount of noise reduction provided, number of people protected*
- *Cost of mitigation - total cost and cost variation with benefit provided*
- *Community views - aesthetic impacts and community wishes*
- *Noise levels for affected land uses - existing and future levels, and changes in noise levels*
- *Benefits arising from the development*

Although the criteria are non-mandatory, they provide the basis for establishing appropriate noise levels that can be incorporated into conditions in development consents issued by consent authorities (such as NSW Planning)...Where noise level conditions are set, they would result from starting with the noise criteria as the targets and then applying all feasible and reasonable measures. Noise levels higher than the criteria may need to be applied as a condition of consent where it is demonstrated that the criteria cannot be met by applying all feasible and reasonable mitigation measures." (ECRTN, p15)

The approach followed during the design stage of the Project is also in line with the ENMM which states:

"It is generally not 'reasonable' to take action to reduce predicted noise levels through the adoption of measures (such as noise barriers/mounds, architectural treatments and quieter pavement surfaces) beyond the adoption of all feasible and reasonable traffic management and other road measures:

[1] For proposed "new" roads and road "redevelopments" the RTA believes it is generally not "reasonable" to take action to reduce predicted noise levels to the target noise levels if the noise levels with the proposal, ten years after project opening, are predicted to be:

- *Within 2 dBA of "future existing" noise levels (the noise levels from existing sources of road traffic noise predicted for the time of project opening), and*
- *No more than 2 dBA above the target noise levels set out in columns 2 and 3 of Table 1 in ECRTN.*

This approach is based on the insignificance of the changes in noise levels involved and the insignificant exceedances of the target noise levels."

(RTA Environmental Noise Management Manual, Practice note iv, p 98)

The design noise criteria used for the assessed residences within each NCA of this Project was determined in the EIA (2002) and is outlined Table 5 above.

It should also be noted that in line with Appendix 4, Clause 4.20, Part (o) of the SWTC, operational noise treatment has been provided to maintain noise levels at noise sensitive receiver locations, at or below the contour lines identified in Figures 20.9 and 20.10 in Appendix 20 of the SWTC.

4.5 Maximum Noise Level Assessment

Maximum noise levels generated by road traffic noise have the potential to cause disturbance to sleep. MCoA 27 does not specifically require an assessment of maximum noise levels to be considered during the development of noise mitigation for sensitive receptors. However, Appendix 4, Clause 4.20, Part (m) of the SWTC does require the assessment of maximum noise levels to evaluate sleep disturbance impacts. Furthermore, the ECRTN also requires maximum noise levels during each hour of the night time period (10:00pm to 7:00am) to be assessed and reported to give an indication of the likelihood of awakening reactions.

The ECRTN does not include noise criteria for assessing maximum noise level events. This is primarily because research conducted to date in this field has not been definitive and the relationship between maximum noise levels, sleep disturbance and subsequent health effects is not currently well defined. Guidelines for assessing maximum noise levels are provided in Practice Note III of the ENMM. The guidelines are to be used as a tool to help prioritise and rank mitigation strategies, but should not be used as a decisive criterion in itself.

The ENMM defines a "maximum noise event" as any pass-by for which:

$$L_{\max} - L_{\text{eq (1hr)}} \geq 15 \text{ dB(A)}, \text{ where the } L_{\max} \text{ noise level is greater than } 65 \text{ dB(A)}.$$

The above is reiterated in the EIA (2002) and in terms of how the night time L_{Aeq} descriptor assists to address the potential for sleep disturbance, it states:

'This suggests that the use of the night time L_{Aeq} descriptor is adequate to assess potential night time impacts from heavy vehicles, in accordance with the ECRTN'.

Therefore, although maximum noise levels are monitored and assessed as part of the post-construction noise assessment, the primary focus is in the assessment of L_{Aeq} night-time noise levels as indicated in the EIS (1998) and the EIA (2002).

4.6 Yelgun Rest Area Assessment

There are no specific goals for addressing noise from rest areas. The Yelgun rest area is in use 24 hours per day. Therefore, in accordance with the Review of Environmental Factors (REF)

prepared by Acacia Environmental Planning Pty Ltd in November 2004, it is appropriate to assess the impact from the Yelgun rest area on the general noise amenity surrounding the site using the NSW Industrial Noise Policy (INP). Furthermore, the REF also provides requirements for the assessment of the potential for sleep arousal, based on the NSW Department of Environmental and Climate Change (DECC) sleep disturbance criteria.

5 PROJECT NOISE MITIGATION MEASURES

The following summarises the noise mitigation measures implemented on this project to reduce noise impacts to receivers.

There has been a number of methods used on this project to mitigate traffic noise, and these include:

1. road design features;
 - increased distance between the road and receivers (eg optimising road alignment, inclusion of landscaped areas and parklands to act as buffers between road and receivers, etc)
 - use of cuttings in road to provide noise shielding
 - shielding from road structures (eg retaining walls, bridge structures etc)
 - selection of quiet expansion joints for bridges
2. low-noise pavement;
3. roadside noise mounds, barriers and walls;
4. fences along residential property boundaries; and
5. architectural or at-dwelling noise control treatment provided by the RTA.

5.1 Road Design Features

Road design features of this Project which assist in reducing traffic noise impacts include:

- Various cuttings and retaining walls which shield the road from residences.
- Noise walls, tall walls (1.1m extended height Type-F barriers) and Type-F barriers (860mm high) which provide shielding of the road from residences.
- Quiet expansion joints for bridges to reduce peak noise levels.

The expansion joints applied are:

- Small movement joints – located at Marshall Creek and Yelgun bridges. The joint blends in with the asphalt surface of the bridge deck generating minimal noise and reducing noise impacts.
- Large movement joints – located at Brunswick River Bridge. Finger plate expansion joints used to allow for large movement. The joints have no metal to metal contacts with the 'fingers' providing a smooth transition over the expansion gap therefore minimising noise and reducing noise impacts.

5.2 Low-Noise Pavements

Approximately 7km of the main carriageway of the Upgrade and each of the on and off ramps between just south of the Brunswick Heads North Interchange and the northern end of the Upgrade at Yelgun was finished with a low noise surface of Stone Mastic Asphalt (SMA), as this section is the most densely populated section of the Upgrade. SMA provides significant and worthwhile noise reduction benefits.

All ramps and the main carriageway between the southern end of the Upgrade and just south of the Brunswick Heads North Interchange (station 42100 to 43950) were finished with plain concrete pavement with a light hessian drag and tining.

5.3 Noise Barriers and Walls

MCoA 31 requires that the following mitigation measures be implemented prior to the commencement of substantial construction, unless otherwise agreed to by EPA:

"a solid barrier along the property boundaries between Rajah Road and Oba Place. In the area directly north of Rajah Road and Arika Avenue (no. 1-3) this will be a barrier of up to 2.5m. For residences in Oola Close, Oba Place and Weeronga Way the barrier will be 2m."

Figure 20.8 in Appendix 20 of the Scope of Work and Technical Criteria also provides minimum at-road noise mitigation measures to be incorporated into the Project.

Noise walls were constructed in accordance with the requirements of the EIA, MCoA 31 and the SWTC.

A detailed environmental noise assessment for the project is documented in Appendix E and Section 5.5 'Noise Mitigation Measures' of the EIA (2002). From the EIA, Section 5.5.2 deals with Project Specific Noise Mitigation Options and Section 5.6 provides details of Design of Feasible and Reasonable Mitigation Measures. Furthermore, a detailed feasibility analysis was completed during the design phase in accordance with Practice Note IV of the ENMM for the central section of the Project, between Brunswick Heads North Interchange and Balemo Drive at representative noise affected dwellings within each NCA at both the Ground Floor (ie. 1.5m above ground level) and First Floor (ie. 4.5m above ground level). The analysis confirmed the optimum noise mitigation requirements, including the appropriate mix of at-road and at-residence treatment identified in the EIA. Due to the steepness of topography surrounding the project, and the limited number of residences along the route experiencing excessive noise levels, it was found that at-residence treatment was required either in addition to or in preference to at-road treatment at most NCAs.

Noise barriers are most feasible where residences are closely grouped, where the barriers do not cause access difficulties to properties, and where they are visually acceptable. To derive the most appropriate height for noise barriers (walls and mounds) for each NCA, a feasibility

analysis was undertaken in accordance with Practice Note IV of the ENMM. A summary of the feasibility analysis and assessment outputs is presented in Annexure I of the ONMR.

In summary, noise barriers and walls have been constructed in accordance with the requirements of the MCoA, the SWTC, the EIA, the ECRTN and the ENMM. The ONMR presents the schedule of the noise barriers and walls that have been installed as part of the project and this schedule is reproduced in **Appendix B** of this report. Annexure B details the location, lengths and heights of noise barriers and the type of noise barriers constructed.

5.4 Architectural or At-Residence Noise Control Treatment

In accordance with Clause 27(e) of the MCoA and Section 4.21 of Appendix 4 of the SWTC, the RTA had identified buildings requiring architectural treatment and carried out negotiations with the community. The buildings to be offered architectural treatment were identified from the outcomes of a study conducted by Wilkinson Murray, and prepared for the EIA (2002), prior to the commencement of construction.

Architectural treatment was offered early for this project to provide benefits to residents from both construction and operational noise, in response to feed back and lessons learnt from other road projects.

Architectural treatment to affected buildings had subsequently been offered to property owners. Buildings with habitable rooms overlooking the highway and not able to benefit substantially from at-road noise mitigation, were provided with noise mitigation in the form of mechanical ventilation/air-conditioning, upgraded glazing and enclosed verandahs, and subfloors where required. The status of residences requiring architectural treatment, and extent thereof, as undertaken by the RTA are presented in a schedule in the ONMR.

The RTA was responsible for the implementation of architectural treatment, and as indicated in Appendix 4, Clause 4.21, Part (a) of the SWTC, AbiGroup was not permitted to undertake any at-residence treatment to affected residences, as they were only required to provide at-road mitigation measures.

A detailed environmental noise assessment for the project is documented in Appendix E and Section 5.5 'Noise Mitigation Measures' of the EIA (2002). From the EIA, Section 5.5.2 deals with Project Specific Noise Mitigation Options and Section 5.6 provides details of Design of Feasible and Reasonable Mitigation Measures. Furthermore, during the detail design phase, an analysis into the design of feasible and reasonable mitigation measures was undertaken in accordance with Practice Note IV of the ENMM. A summary of the feasibility analysis and assessment outputs is presented in Annexure I of the ONMR. Therefore, the process followed for the design of noise mitigation measures for this project, complies with the ENMM as documented in both the EIA and the ONMR.

6 NOISE CATCHMENT AREAS

To facilitate the assessment of noise impacts from the Project, residential and other noise sensitive areas along the route were divided into Noise Catchment Areas (NCAs).

The NCAs identified along the Project route are as follows:

Table 6 – Location of Noise Catchment Areas

Section	Sensitive Receivers and Respective NCAs	
	West of the Upgrade	East of the Upgrade
Brunswick Heads Bypass to south of Brunswick River	Isolated residences in Bashforth Lane (NCA2). Ferry Reserve Caravan Park (NCA3).	Isolated residence Bayside Way (NCA1). Brunswick Heads township.
South of Brunswick River to Coolamon Scenic Drive/ Orana Road	Brunswick Heads Nature Reserve. Residences on Coolamon Scenic Drive and Mountain View Road (NCA9).	Brunswick Heads Nature Reserve. Rajah Road (NCA4). Arika Avenue (NCA4). Oola Place (NCA5). Oba Place (NCA5). Weeronga Way West (NCA5). Weeronga Way East (NCA6). Tongarra Drive (NCA7). Binya Place (NCA8). Yamble Drive (NCA10). Kuringai Way (NCA10).
Coolamon Scenic Drive/ Orana Road to Shara Boulevard	Isolated residences on Billinudgel. Road south (NCA12). Billinudgel Industrial Area. Christian Life Centre, White Dove Funeral Home, Humble Pie Shop (NCA16).	Balemo Drive South (NCA11). Kulgun Court (NCA13). Nargoon Close (NCA14). Ulpira Court (NCA14). Aloota Crescent (NCA14). Matong Drive (NCA 15). Gilba Avenue (NCA17). Balemo Drive north (NCA 18).
Shara Boulevard to Yelgun	Isolated residences on The Pocket Road and Billinudgel Road north (NCA19) (NCA20).	Billinudgel Nature Reserve. Isolated residence 'Jagwen' (NCA21).

Appendix A presents Figures which show the locations and extent of each NCA.

7 NOISE MONITORING

Clause 34 of the MCoA states that post-construction noise monitoring is required to be undertaken once the Upgrade is operational.

The ONMR states that noise monitoring should be conducted within six (6) months of commencement of operation of the Upgrade.

Guidance is taken from the RTA's 'Environmental Noise Management Manual' (ENMM) for the timing and duration of monitoring, and monitoring was undertaken in accordance with Australian Standard 2702-1984 'Acoustics- Methods for The Measurement of Road Traffic Noise'.

The ENMM recommends the following:

"...The monitoring is generally conducted to give a minimum of seven consecutive days of data.

Classified traffic monitoring needs to be conducted simultaneously with the noise monitoring, to identify traffic flows and mixes."

Practice Note VIII of the ENMM gives further guidance for post construction noise monitoring and states:

"Post-construction monitoring is undertaken to determine whether the mitigation measures have been adequate for the predicted design noise levels to be met.

The "Design Noise Level for Year 1" is the noise level for the road development at project opening, after all feasible and reasonable mitigation strategies have been applied.

Provided traffic flows and mixes following the road's opening are in line with those used for the predictions, it can be expected that if the predicted noise levels for Year 1 are achieved the predicted Year 10 noise levels will also be achieved.

It should be recognised that noise prediction modeling has some accuracy limitations and will commonly produce acceptable errors of around 2 dB(A). In addition, when noise levels for a new road are being monitored short-term and uncharacteristic variations in traffic flow need to be taken into account when comparing the measured and predicted noise levels."

A Submissions Report prepared by the RTA in April 2003 provides guidance to where post-construction noise monitoring should be conducted. Response 1 to Representation Number 56 presented in Section 3.2.10 of the report states the following:

"Noise monitoring would be undertaken at the locations monitored in the noise assessments for the original EIS (SKM, 1998) and the recent EIA Document."

Furthermore, specific noise monitoring locations were nominated in the ONMR. These noise monitoring locations have been selected in consultation with the RTA and the DECC to represent the potentially most affected noise sensitive receptors in each Noise Catchment Area (NCA), and to correlate with noise monitoring locations selected prior to construction to enable direct comparison where possible. Further to the noise monitoring locations nominated in the ONMR, additional noise monitoring locations have been selected based on comments and complaints received from the community.

7.1 Noise Monitoring Methodology

The assessment of road noise post-construction is more complex than simply measuring noise levels and comparing these to the project's noise criteria. An integrated approach is required which includes long-term and short-term noise monitoring, classified traffic counting, and noise modelling. While noise measurement can quantify the current traffic noise levels produced by the current volume of traffic, noise modelling is also required to determine future noise levels for the design year (year 2017), and noise levels at locations where noise monitoring is not conducted. Traffic count data is used as an input to the noise model therefore traffic count data (vehicle volumes, composition and speeds) were collected concurrently with the noise monitoring.

Furthermore, comparison of measured and modelled noise levels also allows validation of the noise model used during the design phase of the project and enables the adequacy of the implemented noise mitigation to be thoroughly assessed.

The noise monitoring and assessment procedures followed in this assessment are in accordance with the requirements of the RTA's ENMM's 'Practice Note VIII - Post Construction Noise Monitoring', and guidance was taken from Australian Standard 2702-1984 'Acoustics- Methods for the Measurement of Road Traffic Noise'.

7.1.1 Long-Term Noise Monitoring

All long-term noise monitoring was conducted using Renzo Tonin & Associates' noise loggers. This noise monitoring equipment complies with Australian Standard 1259.2-1990 "Acoustics - Sound Level Meters" and is designated as a Type 2 instrument suitable for field use.

A noise monitor consists of a sound level meter and a computer housed in a weather resistant enclosure. Ambient noise levels are recorded at a rate of 10 samples per second. Every 15 minutes, the data is processed statistically and stored in memory.

A noise monitor was installed at each nominated monitoring location and generally positioned 1m from the most affected facade and at a height of 1.2m to 1.5m above the floor level for a minimum of 7 consecutive days in accordance with the RTA's ENMM. In some instances, the most affected facade was located on the first floor level. In these cases, the noise monitor was accordingly located on the most affected floor level. Furthermore, at some monitoring locations

access restrictions were found in the field and the noise monitor was positioned at the next best location and appropriate adjustments were made to the measured noise levels.

7.1.2 Short-Term Noise Monitoring

Short-term monitoring assists with filling in any gaps between the long-term monitoring locations, it assists with validating the noise model and is used to provide a better understanding of any specific issues at chosen complainant locations. This type of attended monitoring also allows for qualitative assessments to be conducted, which assists in characterising the ambient noise environment of each area. For example, field notes are made on acoustically significant issues, such as vehicles passing over the 'profiled-line-marking' alongside the main carriageways and/or extraneous noise (eg. birds, insects, barking dogs, etc) prevailing at the subject site.

Short-term monitoring was conducted at selected 'satellite' locations nearby to the long-term monitors, and concurrently with the long-term noise monitoring. Short-term noise monitoring was undertaken for a minimum of two consecutive 15-minute sample periods at each satellite location, using Type 1 sound level meters.

7.1.3 L_{Amax} Noise Monitoring

Maximum (L_{Amax}) noise levels from the Upgrade were monitored continuously over night periods (10:00pm to 7:00am) using unattended noise loggers at the same locations where L_{Amax} noise levels were previously measured as described in the ONMR, and were also evaluated in accordance with the objectives set out in the EIA (2002). Each noise logger was positioned 1m from the facade and at a height of 1.2m to 1.5m above floor level. Noise monitoring at these locations (see Chapter 7.2.4) was conducted continuously over periods greater than one week at the long-term noise monitoring locations and over an additional period of one to four nights for three locations where a more detailed L_{Amax} noise level analysis was conducted.

L_{Amax} noise levels from the Yelgun Rest Area was monitored using a Type 1 sound level meter at locations specified in the ONMR and were evaluated in accordance with the objectives set out in the REF (2004) for the assessment of the potential for sleep arousal, based on the DECC's sleep disturbance criteria. Attended L_{Amax} noise level monitoring for the Yelgun Rest Area was undertaken for a minimum of two consecutive 15-minute sample periods. Attended monitoring of the Yelgun Rest Area enabled specific L_{Amax} noise level events (eg. compression braking, door closing, truck engine starting) to be recorded.

7.1.4 Noise Monitors

All acoustic instrumentation employed for the noise monitoring program are designed to comply with the requirements of AS 1259.2-1990 "Acoustics - Sound Level Meters Part 2: Integrating - Averaging" and carry appropriate and current NATA (or manufacturer) calibration certificates.

7.1.5 Meteorology During Monitoring

Measurements affected by extraneous noise, wind (greater than 5m/s at the microphone) or rain were excluded from the recorded data. Meteorological data supplied by The Bureau of Meteorology and data from a weather station located on site for greater accuracy in checking weather conditions closer to the monitoring sites, was analysed for this purpose. It is noted that during noise monitoring in late October to December 2007, there was a large amount of wet and windy weather and as a result the monitoring period was extended to ensure sufficient conforming data was collected.

Noise enhancing or noise diminishing meteorological conditions from winds and temperature inversions do not form part of the requirements of the ECRTN. Furthermore, the ENMM states the following:

'...in most cases the distances involved in traffic noise impact assessments are less than 300 metres from the road, and meteorological conditions have little impact on traffic noise problems over these short distances'.

Given that the traffic noise monitoring was undertaken at distances within 300m from the Project (for all long-term and most of the short-term noise monitoring), noise enhancing or noise diminishing meteorological conditions would have little impact on the measured traffic noise levels.

The EIA, ECRTN and the ENMM do not stipulate the evaluation of road traffic noise under adverse meteorological conditions which may affect traffic noise levels. Notwithstanding this, for roads the worst affected residences are typically closer than 200-300 metres and thus including weather effects in assessing noise levels is not needed. In situations where the worst affected residences are distant from the road, weather effects may, depending on circumstances influence noise levels, by either hindering or assisting with the propagation of traffic noise levels over large distances. However, this tends to only be an issue for projects with very low noise criteria as noise attenuates over large distances. In this case, given that the Upgrade is essentially a redevelopment of an existing highway with significant pre-existing traffic noise levels, influences from meteorological effects are insignificant and do not affect the outcomes of this study.

7.1.6 Noise Monitoring Outputs

The noise monitoring instruments stored L_{A90} , $L_{Aeq,15hr}$, $L_{Aeq,9hr}$ and $L_{A,max}$ noise levels as a minimum on a continuous basis at 15-minute intervals. While measurement results for all these indices were retained, the study primarily focuses on the $L_{Aeq,9hr}$ results as this is the noise assessment index embodied in the NSW Government 'Environmental Criteria for Road Traffic Noise'.

Noise generated by the profile-line-marking existing along the outer edges of the project's road carriageways, designed to warn drivers who may suffer from fatigue, is included in the monitoring results.

Upon processing the noise monitoring data, any 'suspect' data influenced by factors other than road traffic noise such as adverse weather conditions, industrial, commercial, domestic, insects, fauna or other extraneous noise sources unrelated to the project were excluded.

7.2 Noise Monitoring Locations

Long term, short term 'satellite' and L_{Amax} noise monitoring were undertaken at locations selected to represent:

- previously monitored locations presented in the EIS (1998) Working Paper No 3, Noise Impact Assessment – Wilkinson Murray Pty Limited, June 1998 (EIS);
- previously monitored locations presented in the EIA (2002) Noise & Vibration Assessment – Wilkinson Murray Pty Limited, October 2002 (EIA);
- the locations used for the pre-construction noise monitoring and presented in the ONMR representing each Noise Catchment Area (NCA);
- areas where noise modelling for the future, 10 years after road opening (as per the SWTC) has indicated that noise levels will be marginally within 2dB(A) of the set noise criteria, in particular affected residences in NCA 12; and
- areas where complaints of operational traffic noise have been received.

In a few situations where it was not possible to conduct noise monitoring at the previously chosen locations, noise monitors were setup within close proximity to the originally selected locations. In these few situations, noise monitoring was not conducted at the pre-selected locations because of issues concerning accessibility, availability of a secure location for equipment, potential influences from extraneous local non-traffic noise sources (eg domestic animals, residential air-conditioning units, pool pumps, etc), the Upgrade causing different locations to be worst-affected than before, the Upgrade causing a different façade at the same address to be worst-affected, presence of architectural elements that may impact on the measurements (such as newly constructed out-buildings, covered verandahs, large awnings etc) and the like.

Table 7 below presents the alternate locations and the original locations they represent.

Table 7 – Original and Alternate Noise Monitoring Locations

Original Selected Locations	Alternate Locations	Comment
5/1 Rajah Rd	4/1 Rajah Rd	Alternate location directly adjacent to original location and within the same block of units
15/2 Rajah Rd	4/1 Rajah Rd	Alternate location is directly across Rajah Rd to the north of the original location
19 Weeronga Way	21 Weeronga Way	Alternate location directly across Oba Pl to the north of original location. Alternative location consistent with monitoring location in ONMR

Original Selected Locations	Alternate Locations	Comment
1/10-14 Balemo Dr	10/10-14 Balemo Dr	Alternate location within the same townhouse complex as original location
East end Riverside Cr	Ferry Reserve Caravan Park	Exact address of original location unknown. Alternate location is closer to the Upgrade and more affected by traffic noise from the Upgrade
11 Weeronga Way	5 Weeronga Way	Alternate location is two properties to the north of the original location. Alternate location is a complainant of traffic noise from the Upgrade
1 Tongarra Dr	5 Tongarra Dr	Alternate location is two properties to the north of the original location. Alternate location consistent with monitoring location in ONMR
Stock Route Rd (South of Billinudgel)	157 & 175 Billinudgel Rd	Exact address of original location unknown
Stock Route Rd (North of Billinudgel)	Lot 4 (22) Stock Route Rd	Exact address of original location unknown

Where possible, priority and focus for selection of measurement locations was given to properties where complaints had been received from the community. This provides an opportunity for Abigroup and the RTA to address specific areas of concern raised by the community promptly and responsively. As far as practical, measurement locations were also selected at complainant's properties in order to provide information that would be most relevant to addressing the specific issues raised by these residents. Complainant's properties were considered in prioritising the short-term 'satellite' monitoring locations.

Once these complainant locations were identified, additional locations were selected to achieve a relatively even distribution of survey locations within each NCA. Close spacing of locations ensures confidence in the interpolation of noise levels at intervening properties where no specific noise measurements were conducted.

Furthermore, in accordance with the Submission Report (April 2003) prepared by the RTA, previously monitored locations presented in the EIS document (1998) and the EIA document (2002) were considered and where appropriate, noise monitoring locations presented in the EIS and EIA were re-monitored.

As well as having regard to the pre-construction measurement locations presented in the ONMR, EIS and EIA and the prioritisation of complainant residences, the noise monitoring locations were selected with the aim of providing relatively evenly-spaced coverage of affected properties nearest to the road corridor (including the Brunswick Valley Way). Various noise monitoring locations were selected to represent properties located behind noise barriers. These locations would provide an indication of the adequacy of the traffic noise mitigation measures provided (ie. the acoustic benefits provided by the noise barriers).

7.2.1 Post-Construction Operational Long Term Noise Monitoring Locations

The selected locations for post-construction long term unattended noise monitoring are listed in Table 8. The selected long term unattended monitoring locations are numbered and marked with a 'blue circle' on the maps in **Appendix A**.

Following a review of the proposed monitoring program by the RTA and DECC, post-construction operational noise monitoring commenced in October 2007 and ended in December 2007.

The monitoring was generally conducted in three zones, with one zone monitored at a time. The zones were as follows, starting at the southern end of the Project:

- Zone 1 – Southern end of Project to Binya Place
- Zone 2 – Mountain View Road to The Tunnel Road
- Zone 3 – Matong Drive to Northern end of Project

Table 8 – Post-Construction Long Term Unattended Noise Monitoring Locations

Location No.	Noise Catchment Area (NCA)	Address	Facade of House	Start	Finish
1	-	82 The Saddle Road	East	23/10/2007	12/11/2007
2	NCA 3	Ferry Reserve Caravan Park	Free-Field (roof of Amenities block)	23/10/2007	12/11/2007
3	NCA 4	Unit 4/ 1 Rajah Road	West	23/10/2007	13/11/2007
4	NCA 5	1 Oola Place	West	23/10/2007	12/11/2007
5	NCA 7	21 Weeronga Way	West	23/10/2007	12/11/2007
6	NCA 7	5 Tongarra Drive	West	23/10/2007	12/11/2007
7	-	Dr Holmes, Banana Road	East	23/10/2007	12/11/2007
8	NCA 10	48 Yamble Drive	West	13/11/2007	29/11/2007
9	NCA 9	19 Mountain View Drive	East	13/11/2007	27/11/2007
10		16 Benjamin Lane	East	13/11/2007	27/11/2007
11	NCA 11	10/10-14 Balemo Drive	West	13/11/2007	27/11/2007
12	NCA 13	15 Nargoan Court	West	13/11/2007	27/11/2007
13	NCA 12	Taylor's, The Tunnel Road	East	13/11/2007	27/11/2007
14		Moore's, The Tunnel Road	East	16/11/2007	27/11/2007
15	NCA 15	34 Matong Drive	West	13/11/2007	27/11/2007
16	NCA 18	123 Balemo Drive	West	27/11/2007	11/12/2007
17	NCA 16	Christian Life Centre, 11 Mogo Place	East	27/11/2007	11/12/2007
18	NCA 19	175 Billinudgel Road	East	27/11/2007	07/12/2007
19		157 Billinudgel Road	East	27/11/2007	11/12/2007
20	NCA 21	Jagwen, Billinudgel	South	27/11/2007	11/12/2007
21	NCA 20	Lot 4 (22) Stock Route Road	East	27/11/2007	11/12/2007

7.2.2 Short-term Noise Monitoring Locations

The selected 'satellite' locations for post-construction short term attended noise monitoring are listed in Table 9 below. Short-term monitoring locations are shown with a 'green' circle on the maps in **Appendix A**.

Short term monitoring was also conducted in three zones in conjunction with the long term monitoring. The zones are identical to those chosen for the long term monitoring locations.

Table 9 – Post-Construction Short Term Attended ‘Satellite’ Noise Monitoring Locations

Location No.	Noise Catchment Area (NCA)	Address	Facade of House	Date
S1	-	2 Cudgen Street	West	07/11/2007
S2	-	Brunswick Heads Nature Reserve	Free field (on access road)	07/11/2007
S3	NCA 3	5 Akira Avenue	West	07/11/2007
S4	-	4 Katya Court	West	04/12/2007
S5	NCA 6	5 Weeronga Way	West	07/11/2007
S6		1 Putta Place	West	07/11/2007
S7		15 Weeronga Way	West	07/11/2007
S8	NCA 7	42 Tongarra Drive	West	07/11/2007
S9	NCA 10	58 Yamble Drive	West	20/11/2007
S10		33 Yamble Drive	West	20/11/2007
S11	NCA 14	12 Alooata Crescent	West	20/11/2007
S13	NCA 12	Prokop’s, The Tunnel Road	East	21/11/2007
S14		Nolan’s, The Tunnel Road	East	21/11/2007
S12	NCA 17	21 Gilba Avenue	West	03/12/2007

7.2.3 Complaints-Driven Noise Monitoring Locations

Consideration was given to monitoring of noise levels where complaints of traffic noise have been received and the monitoring locations listed above include locations selected based on complaints. The noise complaint database held by Abigroup was reviewed and each complaint location was sighted to determine the appropriateness of that location for monitoring. In areas where monitoring was to take place, a complainants house was selected if suitable.

In order to provide noise monitoring data at as many complaint locations as possible, a long term noise monitor along with short term ‘satellite’ locations was used where monitoring was required at several locations within the same NCAs.

7.2.4 L_{Amax} Noise Monitoring Locations

To assess post-construction L_{Amax} noise levels, two approaches have been followed:

1. an evaluation of the L_{Amax} noise levels measured at the long-term noise monitoring locations to compare to the pre-construction levels monitored for the EIS and EIA and to the levels measured by Renzo Tonin & Associates immediately prior to construction commencement in 2005, and
2. a more detailed analysis at three locations to assess impacts from the Upgrade and a further three locations to assess impacts from the Yelgun Rest Area in accordance with the REF, as described in the ONMR.

The long-term noise monitoring locations for the post-construction noise assessment are listed in Table 8 of this report.

The selected locations and monitoring periods for the more detailed post-construction L_{Amax} noise monitoring are listed in Table 10 below. The more detailed L_{Amax} noise monitoring was also conducted in three zones, which were identical to the three zones chosen for the long term monitoring locations. The more detailed L_{Amax} noise monitoring locations are shown with a 'yellow' circle on the maps in **Appendix A**.

Table 10 – Post-Construction L_{Amax} Noise Monitoring Locations & Periods

Location No.	L_{Amax} Noise Source	Address	Facade of House	Start	Finish
LM1	Upgrade	Unit 4/ 1 Rajah Rd	West	29/11/07	30/11/07
LM2	Upgrade	50 Tongarra Drive	West	06/11/07	10/11/07
LM3	Upgrade	48 Yamble Drive	West	27/11/07	29/11/07
LM4	Yelgun Rest Area	Holm Farm, 157 Billinudgel Rd	North*	04/12/07	04/12/07
LM5	Yelgun Rest Area	Jagwen, Billinudgel Rd	North*	03/12/07	04/12/07
LM6	Yelgun Rest Area	Lot 4 (22) Stock Route Rd	Southeast*	04/12/07	04/12/07

*Note: * Façade selected which is worst-affected by noise from the Yelgun Rest Area*

7.3 Traffic Volumes, Classification and Speed Monitoring

7.3.1 2007 Traffic Data

Traffic volumes, classification of vehicles and vehicle speeds were monitored concurrently with the noise monitoring. This is a requirement of Practice Note VIII of the RTA's ENMM and the data allows final noise levels to be compared to the SWTC traffic data used as inputs to the noise modelling.

The locations where traffic counting was conducted are listed below and are shown on the maps in **Appendix A**.

Main Alignment

Site A –	Approximately 1.2km north of Brunswick Heads South Interchange
Site B –	Approximately 20m south of the access road underpass/ overpass to the Sewerage Treatment Plant
Site C –	Approximately 20m south of Marshalls Creek bridge
Site D –	Approximately 300m north of the northbound onload ramp of the Yelgun interchange

Brunswick Valley Way and Yelgun Rest Area

Site E –	On Brunswick River bridge
Site F –	Adjacent to water tank

Site G –	Approximately 500m north of Orana Rd
Site H –	Approximately 150m south of Wilfred St (between Wilfred St and underpass to Bonanza Dr)
Site I –	Approximately 20m south of Marshalls Creek bridge
Site J –	Entry to Yelgun Rest Area
Site K –	Approximately 50 north of Stock Route Road underpass/ overpass

Table 11 presents the counted night-time (9hr) 2007 traffic volumes and vehicle speeds (based on an 85 percentile) at various locations along the upgrade used to validate the noise model against the concurrently measured 2007 monitored noise levels. The dates shown represent the specific periods that the noise monitoring was conducted for each monitoring zone.

Table 11 – Counted 2007 Night Time (9hr) Traffic Volumes used for Noise Model Validation

Traffic Counting Location	Date of Traffic Counts	Total Vehicles	Heavy Vehicles	Vehicle Speeds ¹
Zone 1 23/10/07 TO 12/11/2007				
<i>Pacific Highway Upgrade</i>				
Brunswick Heads South Interchange to Brunswick River	23/10/07 to 12/11/07	2544	743	113
Brunswick River to Wilfred St Intersection		2139	718	113
<i>Brunswick Valley Way</i>				
Brunswick Heads North Interchange to Rajah Rd Intersection	23/10/07 to 12/11/07	809	47	65
Rajah Rd Intersection to Orana Rd Intersection		346	27	84
Zone 2 – 13/11/07 TO 27/11/07				
<i>Pacific Highway Upgrade</i>				
Brunswick River to Wilfred St Intersection	13/11/07 to 27/11/07	1792	665	112
	13/11/07 to 29/11/07	2110	713	111
	16/11/07 to 27/11/07	2052	641	111
Wilfred St Intersection to Yelgun Interchange	13/11/07 to 27/11/07	2069	756	116
	13/11/07 to 29/11/07	2082	779	119
	16/11/07 to 27/11/07	2025	705	116
<i>Brunswick Valley Way</i>				
Brunswick Heads North Interchange to Rajah Rd Intersection	13/11/07 to 27/11/07	916	56	66
Rajah Rd Intersection to Orana Rd Intersection	13/11/07 to 27/11/07	359	31	86
	13/11/07 to 29/11/07	367	34	86
Orana Rd Intersection to Bonanza Dr Unerpass	13/11/07 to 27/11/07	512	45	82
	13/11/07 to 29/11/07	518	46	82
	16/11/07 to 27/11/07	465	34	83
Bonanza Dr Underpass to Balemo Dr Intersection	13/11/07 to 27/11/07	548	48	84
	13/11/07 to 29/11/07	548	46	82

Traffic Counting Location	Date of Traffic Counts	Total Vehicles	Heavy Vehicles	Vehicle Speeds ¹
Zone 3 – 27/11/07 TO 11/12/07				
Pacific Highway Upgrade				
Brunswick River to Wilfred St Intersection	27/11/07 to 11/12/07	2211	651	109
Wilfred St Intersection to Yelgun Interchange	27/11/07 to 11/12/07	2066	757	115
	27/11/07 to 7/12/07	2110	811	117
Yelgun Interchange to Northern End of Upgrade	27/11/07 to 11/12/07	2044	723	113
Brunswick Valley Way				
Bonanza Dr Underpass to Balemo Dr Intersection	27/11/07 to 11/12/07	553	50	85
Balemo Dr Intersection to Yelgun Interchange	27/11/07 to 11/12/07	490	44	88
	27/11/07 to 7/12/07	528	51	86
Yelgun Interchange to Northern End of Upgrade	27/11/07 to 11/12/07	441	57	93

Notes: 1. Vehicle speed based on the average of the northbound and southbound 85th Percentile speeds

For traffic flows counted during post construction noise monitoring, Practice Note VIII of the ENMM, states:

“In addition, when noise levels for a new road are being monitored short-term and uncharacteristic variations in traffic flow need to be taken into account when comparing the measured and predicted noise levels.”

As the post-opening traffic counting was conducted in late October through to December 2007, which is a busy time of the year for the Pacific Highway north of NSW, the counted traffic data requires adjustment for this busy season to normalize the data and convert it to Annual Average Daily Traffic (AADT) data.

7.3.2 2017 Traffic Data

It is noted that the assessment of noise from the Upgrade is based on predicted traffic volumes for 10 years after the opening of the Upgrade. Traffic data presented in the SWTC is for a design year of 2016, based on the Upgrade opening to traffic in 2006. However, the Project was opened in 2007, while the SWTC traffic data was for the intended year of opening (2006) and ten years after the intended year of opening (2016). Given that the opening of the Upgrade to traffic did not occur until 2007, this results in 2017 being the applicable assessment year.

Since 2017 is the assessment year, the applicable traffic data for 2017 was re-forecast by the RTA. 2007 traffic data monitored concurrently with the post construction noise monitoring was analysed by the RTA and converted to representative AADT data and was then compared to previously forecast 2006 AADT data. The comparison allowed the RTA to more accurately re-forecast the traffic data to determine 2017 AADT traffic data. From the re-forecast 2017 AADT, traffic data for the applicable periods of assessment (ie. day and night) were calculated and the

RTA has provided the traffic forecasts for 2017 which have been used in the noise predictions for 2017, 10 years after opening.

Once the noise model was validated using the 2007 noise monitoring results and the 2007 traffic volumes presented above, noise predictions for year 2017 were conducted using the re-forecast night-time (9hr) 2017 traffic volumes provided by the RTA. The RTA re-forecast 2017 traffic volumes used in the design are presented in Table 12 below.

An analysis of the 2007 monitored traffic speed data has determined the 85 percentile vehicle speed for the 9 hour night-time period to be 112 km/h for the Upgrade, 83km/h for the Brunswick Valley Way north of Rajah Road and 66km/h for the Brunswick Valley Way south of Rajah Road.

Table 12 – 2017 Night Time (9hr) Traffic Volumes used for Post-Construction Noise Assessment

Location		Total Vehicles	Heavy Vehicles
Pacific Highway Upgrade			
Brunswick Heads South Interchange to Brunswick River	NB	1522	600
	SB	1461	312
Brunswick River to Wilfred St Intersection	NB	1293	546
	SB	1228	288
Wilfred St Intersection to Yelgun Interchange	NB	1278	538
	SB	1218	360
Yelgun Interchange to Northern End of Upgrade	NB	1347	572
	SB	1105	291
Brunswick Valley Way			
Brunswick Heads North Interchange to Rajah Rd Intersection	NB	377	28
	SB	655	33
Rajah Rd Intersection to Orana Rd Intersection	NB	163	19
	SB	285	18
Orana Rd Intersection to Bonanza Dr Underpass	NB	271	22
	SB	297	26
Bonanza Dr Underpass to Balemo Dr Intersection	NB	228	22
	SB	363	30
Balemo Dr Intersection to Yelgun Interchange	NB	246	22
	SB	294	26
Yelgun Interchange to Northern End of Upgrade	NB	200	21
	SB	252	39

It is noted that the forecast 2017 traffic data presented above is considered conservatively high and that it would take a large increase in traffic volumes to cause a slight increase in noise level. For example, a doubling of traffic volumes would constitute a 3dB(A) increase in noise level.

8 NOISE ASSESSMENT METHODOLOGY

8.1 Overview

The steps followed in this post-construction operational noise assessment process were:

- Measure traffic noise levels during operation of the road at locations representative of a group of properties located in the vicinity of the noise monitoring location;
- Measure traffic volumes, classifications and speeds concurrently with noise monitoring;
- Validate the noise model that was established during the design phase of the project using the measured noise levels and measured traffic data;
- Using the validated noise model and revised traffic data forecasts, determine the post-construction 2017 noise levels at the sensitive receivers presented in Table E.1 of the ONMR and determine the difference between the post-construction 2017 noise levels and the design stage predicted 2016 noise levels for each sensitive receiver, and compare the 2017 noise levels to the EIA noise criteria and 2016 predictions;
- Where the variance between the design noise model and the post-construction noise model are greater than +2dB(A) [representing acceptable error for noise prediction modelling as per Practice Note VIII of ENMM], determine if there is a clear trend in traffic noise levels being higher than predictions; and
- Using the validated noise model, prepare $L_{Aeq(9hr)}$ noise contours for the 2017 design year to compare with the noise contour lines identified in Figures 20.9 and 20.10 in Appendix 20 of the SWTC.

More details are provided below on the handling of measured noise levels and in assessing compliance and outcomes of this study.

8.2 Measured Noise Levels

To determine "measured" (year 2007) noise levels at potentially affected properties in each NCA, generally the following steps were carried out:

- The recorded short-term $L_{Aeq(15\text{ minute})}$ noise level measured over two 15 minute periods at each 'satellite' location were linked to the closest and/or most representative long-term noise monitoring location where $L_{Aeq(9\text{ hour})}$ noise levels are measured over a minimum of 7 nights. This was done by obtaining the difference between the corresponding L_{Aeq} noise levels recorded at the closest and/or most representative long-term location and the L_{Aeq} levels recorded at the 'satellite' or short-term locations on the same night during the corresponding 15 minute periods.

- These differences (whether positive or negative) were then applied to the overall night-time year 2007 long-term $L_{Aeq(9hour)}$ noise level at the closest and/or most representative long-term location to give a “correlated” $L_{Aeq(9hour)}$ at the ‘satellite’ noise monitoring locations. That is, as if there had been a long-term noise monitor at the ‘satellite’ or short-term measurement location.
- Thereby, an equivalent year 2007 $L_{Aeq(9hour)}$ noise level was derived for each ‘satellite’ noise measurement location.

Furthermore, it is also noted that in this assessment, a greater emphasis was placed on long-term noise monitoring results rather than on short-term monitored results when determining outcomes, because long-term monitoring better handles short-term sporadic traffic fluctuations.

8.3 Compliance Assessment

Noise modelling predictions are based on a method developed by the United Kingdom Department of Environment entitled “Calculation of Road Traffic Noise (1988)” known as the CoRTN (1988) method. This method has been adapted to Australian conditions and extensively tested by the Australian Road Research Board and as a result it is recognised and accepted by the RTA, DECC and DoP. The model predicts noise levels for steady flowing traffic and noise from high truck exhausts is also taken into account.

The CoRTN algorithms are contained within the ‘SoundPLAN’ noise modelling software. SoundPLAN noise level calculations consist of a source model and propagation calculations. SoundPLAN can generate noise levels at single points in the model with roads as noise sources. It can also generate noise contours by performing point receiver calculations on a grid of points and interpolating for noise levels between the grid points.

The Renzo Tonin & Associate’s SoundPLAN noise model, using the CoRTN road traffic noise prediction algorithms, was used during the project’s design phase to predict the design year (2016) noise levels. This same SoundPLAN model was used in the ‘normalising’ process (incorporating any changes to as-built roadway acoustical features that changed from the original design features). The model includes inputs of topography, buildings, road surface, road design, landscape/noise mounds and noise walls.

To assess compliance and outcomes, the general approach followed was:

- Measure road traffic noise levels over a representative survey period as described above and averaging the noise levels logarithmically over that period where appropriate (long term surveys).
- Measure the traffic flow, mix characteristics and speeds prevailing at the exact time as the noise measurements (averaging over several days for the long term surveys).

- Calibrate the measured noise levels to the traffic flows, compositions and speeds measured on the same nights as the noise measurements.
- Enter the actual 2007 traffic flow data into the project's SoundPLAN computer model, to determine the difference between the monitored 2007 noise levels and the SoundPLAN-generated 2007 noise levels.
- Apply the difference to the 2017 year predicted noise levels using the post-construction traffic flow figures forecast by the RTA for 2017 and presented in above, and the actual traffic speeds monitored during the post-construction traffic monitoring, to arrive at the 2017 predicted noise levels for sensitive receivers identified in Table E.1 of the ONMR.
- Compare the 2017 noise levels to the EIA noise criteria and 2016 predictions;
- Compare the 2017 year traffic noise levels with the traffic noise levels predicted for the sensitive receivers identified in Table E.1 of the ONMR and noting any variances greater than +2dB(A).
- Determine the mean difference and use it to generate night time $L_{Aeq(9hr)}$ noise contours for the 2017 design year (using the forecast traffic flow figures determined by the RTA for 2017 and presented in Table 12 above), which are used to compare to the noise contour lines identified in Figures 20.9 and 20.10 in Appendix 20 of the SWTC.

Following the above steps, the noise assessment yields the critical night-time $L_{Aeq(9hr)}$ traffic noise levels normalised to Annual Average Daily Traffic flows for the year 2017. It is noted that night-time $L_{Aeq(9hr)}$ traffic noise levels control the assessment outcomes at all relevant residential locations.

8.3.1 Step-by-Step Description of Methodology

The operational noise compliance assessment procedures involve many steps and are not simply a case of deploying noise survey equipment and observing the measured noise levels.

The methodology used to determine a 'validation difference' between the 2007 monitored noise levels and the 2007 modelled noise level for each monitoring location is presented below and was performed once the noise survey equipment was retrieved from a monitoring location and the results were downloaded and analysed.

The following formula was then used to determine the 'mean validation difference':

$$VD_{\text{mean}} = \frac{\sum (2007 M - 2007 C)}{N}$$

where:

- **2007 M** = "Measured 2007" – the raw noise level measured over the noise survey period at the monitoring location.
- **2007 C** = "Computed 2007" – this involves entering the actual traffic volumes, compositions and speeds measured during the noise survey period into the Project's SoundPLAN model used during the design stage and computing the traffic noise level at the same location as where the noise monitoring was conducted.
- **N** = number of monitoring locations (long term and short term)
- **VD_{mean}** = "Mean Validation Difference" – the mean noise level difference between the computer model and the 'real-life' situation using the same traffic flows over all of the monitored locations.

The calculated VD_{mean} value was then inputted into the Project SoundPLAN model to generate noise contours for the night-time period to compare with the noise contour lines identified in Figures 20.9 and 20.10 in Appendix 20 of the SWTC accordingly.

Furthermore, below is a step-by-step description of the methodology that was applied for the comparison of predicted design stage noise levels with the modelled post-construction noise levels for the residences identified in Table E.1 of the ONMR.

In order to take into account:

- Variances in traffic flows during the noise survey periods at different residences; and
- Variances in traffic flows on the nights of measurement and the 2016 ONMR predicted traffic flows,

the following formulae have been used in the assessment at all the residences identified in Table E.1 of the ONMR:

$$\mathbf{2017\ A = (2007\ M - 2007\ C) + 2017\ F}$$

where:

- **2007 M** = "Measured 2007" – the raw noise level measured over the noise survey period relevant to each assessment location.
- **2007 C** = "Computed 2007" – this involves entering the actual traffic volumes, compositions and speeds measured during the noise survey period into the Project's SoundPLAN model used during the design stage and computing the raw (uncorrected) traffic noise level at each assessment location.
- **2017 F** = "Forecast 2017" – the noise level from the Project SoundPLAN design model with the RTA's post-construction forecast 2017 traffic volumes, compositions and speeds at each assessment location, 10 years after opening.

- **2017 A** = "Assessed 2017" - this is the bottom line validated noise level that uses the RTA's post-construction forecast 2017 traffic volumes, compositions and speeds, from which conformance with design intent is determined at each assessment location, 10 years after opening.

The variance or difference found between the measurements and the model at each receiver location, which establishes the accuracy of the noise model used in the acoustic design of the Project is determined by:

$$V = 2017 A - 2016 D$$

Where:

- **V** = "Variance" or difference between the noise level from the Project design model (2016 D) and the noise level from the assessed and validated post-construction model (2017 A) at each assessment location.
- **2016 D** = "Design 2016" - the noise level from the Project SoundPLAN design model with the 2016 SWTC traffic volumes, compositions and speeds (ie as per the ONMR) at each assessment location.

Worked Example:

- | | |
|---|---|
| • 2007 M = 52.0 dB(A) | raw traffic noise level measured over the noise survey period in 2007 relevant to the assessment location |
| • 2007 C = 53.1 dB(A) | computed 2007 SoundPLAN raw traffic noise level using the actual traffic volumes, compositions and speeds measured during the noise survey period at the same assessment location |
| • (2007 M - 2007 C) = (52.0 - 53.1) = -1.1dB(A) | traffic noise modelling adjustment (physical discrepancies between computer model and 'real-life' situation with same traffic flows) at the assessment location |
| • 2017 F = 54.8 dB(A) | 2017 traffic noise level from the SoundPLAN design model with the post-construction forecast 2017 traffic volumes, compositions and speeds at the assessment location |
| • 2016 D = 52.8 dB(A) | design 2016 traffic noise level from the SoundPLAN design model with the 2016 traffic volumes, compositions and speeds (ie as per the SWTC and ONMR) at the assessment location |
| • 2017 A = -1.1 + 54.8 = 53.7 dB(A) | 'assessed 2017' noise level on which conformance with design intent is determined and consideration of possible further acoustical treatment is based upon at the assessment location |

Conformance with the design intent is determined by comparing 2017 A with 2016 D and calculating the variance "V", despite the fact that traffic data used for the Upgrade were lower in 2016 than the post-construction re-forecast traffic data for 2017.

$$V = (2017 A - 2016 D)$$

$$V = 53.7 - 52.8 \text{ dB(A)} = \mathbf{0.9 \text{ dB(A)}}$$

In this case therefore, the "Design 2016" traffic noise level of 52.8 dB(A) was an under-prediction of the actual acoustical outcome of 53.7 dB(A) – ie the "Assessed 2017" of 53.7 dB(A) at this residence is 0.9 dB(A) higher than the 52.8 dB(A) level predicted during the design stage of the Project. However, given that the "Design 2016" level is within an accepted tolerance of 2dB(A) (as per Practice Note VIII of the ENMM) to the "Assessed 2017" level, then this is deemed to conform to the design intent. Furthermore, this residence would not require consideration for additional noise treatment to what has / hasn't been recommended for during the design stage (as per the ONMR).

Furthermore, the "Assessed 2017" (2017 A) traffic noise levels are compared to the project noise level objectives to assess compliance.

8.4 L_{Amax} Noise Assessment

8.4.1 Due to Upgrade

L_{Amax} events from the Upgrade were generally from heavy vehicles passing by the monitoring location and/or vehicles traveling over the profile-line-marking.

The L_{Amax} noise levels measured at the long-term noise monitoring locations were compared to the pre-construction levels monitored for the EIS and EIA and to the levels measured by Renzo Tonin & Associates immediately prior to construction commencement in 2005.

The monitoring locations chosen for the detailed analysis of post construction operational L_{Amax} noise levels were identical to the locations monitored in 2005 as per Table 10 above. The noise assessment presented in this report compares the L_{Amax} noise levels monitored during the post-construction operation of the Project with those monitored during the design stage of the Project.

8.4.2 Due to Yelgun Rest Area

L_{Amax} events from the Yelgun Rest Area were generally from vehicles (heavy and light) using the area. To determine the type of activities occurring within the rest area, attended measurements of L_{Amax} levels were conducted at the selected locations and the corresponding activity was noted. Measured L_{Amax} noise levels were then compared to the noise objectives set out in the REF and described in the ONMR, to assess impacts from the Yelgun Rest Area.

9 RESULTS OF ROAD TRAFFIC NOISE ASSESSMENT

9.1 SoundPLAN Design Model Validation Results

Based on the above methodology, Table 13 presents the results of the validation process by comparing the measured 2007 results to the computed raw (uncorrected) computed results of 2007, using the 2007 traffic volumes, compositions and speeds as measured.

Table 13 – Results of SoundPLAN Design Model Validation

Address	Night L _{Aeq} (9hr) Traffic Noise Level, dB(A)		
	Measured Post Opening Levels at Facade (2007 M) ¹	Computed Raw Post Opening Levels at Facade (2007 C)	Validation Difference = Measured – Computed
Long Term Unattended Noise Monitoring Locations			
82 The Saddle Road, Brunswick Heads	47.5	51.3	-3.8
Ferry Reserve Caravan Park	56.3	57.6	-1.3
Unit 4/ 1 Rajah Road, Ocean Shores	57.4	56.5	0.9
1 Oola Pl, Ocean Shores	58.8	57	1.8
21 Weeronga Way, Ocean Shores	54.5	56.8	-2.3
5 Tongarra Dr, Ocean Shores	60.6	62	-1.4
Dr Holmes Residence, Banana Rd, Ocean Shores	47.5	51.7	-4.2
48 Yamble Dr, Ocean Shores	58.5	58.9	-0.4
19 Mountain View Dr, Billinudgel	52.6	54.5	-1.9
16 Benjamin Lane, Billinudgel	45.4	46.1	-0.7
10/10-14 Balemo Dr, Ocean Shores	54.5	53.3	1.2
15 Nargoan Court, Ocean Shores	53.7	53.8	-0.1
Taylor's Residence, The Tunnel Rd, Billinudgel	53.2	56.9	-3.7
Moore's Residence, The Tunnel Rd, Billinudgel	49.1	51.6	-2.5
34 Matong Dr, Ocean Shores	54.2	53.9	0.3
123 Balemo Dr, Ocean Shores	54.0	58.6	-4.6
Christian Life Centre, 11 Mogo Pl, Billinudgel	65.4	64.2	1.2
175 Billinudgel Rd, Billinudgel	65.3	62.7	2.6
Holm res., 157 Billinudgel Rd, Billinudgel	51.4	52.5	-1.1
Jagwen, Billinudgel Rd, Billinudgel	55.4	54.3	1.1
Lot 4 (22) Stock Route Rd	56.6	58.2	-1.6
Short Term Attended Noise Monitoring Locations			
2 Cudgen Street, Brunswick Heads	47.5	49.1	-1.6
Brunswick Heads Nature Reserve (road)	53.1	52.5	0.6
5 Arika Avenue, Ocean Shores	58.1	57.6	0.5
4 Katya Court	44.0 ²	N/A ³	N/A ³
5 Weeronga Way, Ocean Shores	51.6	51	0.6
1 Putta Place, Ocean Shores	52.3	52.7	-0.4

Address	Night $L_{Aeq(9hr)}$ Traffic Noise Level, dB(A)		
	Measured Post Opening Levels at Facade (2007 M) ¹	Computed Raw Post Opening Levels at Facade (2007 C)	Validation Difference = Measured – Computed
15 Weeronga Way, Ocean Shores	48.9	49.2	-0.3
42 Tongarra Drive, Ocean Shores	46.2	51	-4.8
58 Yamble Dr, Ocean Shores	55.1	60.1	-5.0
33 Yamble Dr, Ocean Shores	50.8	54.5	-3.7
12 Aloota Crescent, Ocean Shores	45.0	44.4	0.6
21 Gilba Avenue, Ocean Shores	50.4	57.7	-7.3
Prokop's Residence, The Tunnel Rd, Billinudgel	43.6	47.8	-4.2
Nolan's Residence, The Tunnel Rd, Billinudgel	50.4	51	-0.6
Mean Validation Difference (VD_{mean}) :			-1.3
Standard Deviation:			2.3

1. 2007M values are raw (as measured) without normalising to account for additional traffic in that period along Pacific Highway north of NSW, and without converting to represent AADT noise levels
2. Measured noise level represents total ambient noise level (inclusive of traffic)
3. N/A due to large distance (~900m) from project and very low monitored traffic noise levels

As reported in the ONMR, the accuracy of the CoRTN algorithms is generally expected to predict noise levels that are within $\pm 3\text{dB(A)}$ of the true noise levels in practice. The results presented in Table 13 above indicate that the validation differences for most monitoring locations fall within those limits and therefore are considered acceptable.

However, modelled noise levels at four long term and five short term locations were determined to vary by more than 3dB(A) from the measured levels. Although the differences were larger, the noise model was predicting higher noise levels than the monitored noise levels, which indicates that the noise model is 'over predicting', thus resulting in conservatively higher noise levels than that which were measured. Reasons for this 'over prediction' may partly be due to the addition of corrections to the noise model at the design stage as reported in the ONMR, which were $+1.2\text{dB(A)}$ for calibration of the model and $+1.6\text{dB(A)}$ [one standard deviation] to give 84% confidence in achieving the modelled night-time $L_{Aeq(9hr)}$ noise results in the field.

Additional reasons are explained below for each location:

Long Term Monitoring Locations

- **82 The Saddle Road, Brunswick Heads** – The high validation difference may have been due to this location being greater than 400m from the Upgrade and the reduced accuracy of the noise model beyond 300m from the traffic noise source, which is acknowledged by the RTA's ENMM document.
- **Dr Holmes Residence, Banana Rd, Ocean Shores** – This monitoring location is located within a valley below the road level and surrounded by dense bush. The effects of the bush

would have provided some reductions in the measured noise levels that are not accurately accounted for in the noise model.

- **Taylor's Residence, The Tunnel Rd, Billinudgel** – There is dense bush between this monitoring location and the Upgrade. Measured noise levels were potentially influenced by noise reductions provided by the dense bush areas that are not accurately accounted for in the noise model.
- **123 Balemo Dr, Ocean Shores** – The noise monitor at this location was located on the first floor balcony which faces north as it was the only safe and secure location available for the monitoring equipment. Minor shielding due to the dwelling from traffic noise south of the property would potentially have influenced the measured noise levels.

Short Term Measurement Locations

A general note that applies to all of the locations below, is that short-term noise measurements do not present $L_{Aeq(9hr)}$ traffic noise levels as accurately as long-term noise monitoring does, because short-term noise measurements cannot account for fluctuations in traffic flows that occur over time.

- **42 Tongarra Drive, Ocean Shores** – The land between the monitoring location and the Upgrade is undulating and given the resolution of the topographic data in the noise model is 2m, the changes in the topography between the monitoring location and the Upgrade would not have been represented accurately in the noise model.
- **58 Yamble Dr, Ocean Shores** – This monitoring location is located above both the Upgrade and the Brunswick Valley Way with intervening land undulations. Since a 2m resolution is provided by the topographic data, the change in topography of the land would not have been accurately represented in the noise model.
- **33 Yamble Dr, Ocean Shores** – This monitoring location is situated two residential blocks from the Upgrade. Other dwellings and undulating land intervening between this location and the Upgrade may not have been accurately represented in the noise model.
- **21 Gilba Avenue, Ocean Shores** – Monitoring location is located above the Upgrade with undulating land in between. Due to the 2m resolution of the topographic data, the change in actual topography may not have been accurately represented in the noise model. Furthermore, this short term location was correlated with the long-term monitored noise levels of 123 Balemo Drive, which also has a significant validation difference.
- **Prokop's Residence, The Tunnel Rd, Billinudgel** – This location is greater than 300m from the Upgrade and given the reduced accuracy of the noise model beyond 300m from the traffic noise source, modelled noise levels are significantly different to measured noise levels. There is also dense bush areas between this monitoring location and the Upgrade which are not accounted for in the noise model. Furthermore, this short term location was

correlated with the monitored noise levels of Taylor’s Residence, The Tunnel Rd, which also has a significant validation difference.

Figure 1– Comparison between 2007 Calibrated Modelled and 2007 Measured $L_{Aeq(9hr)}$ Noise Levels

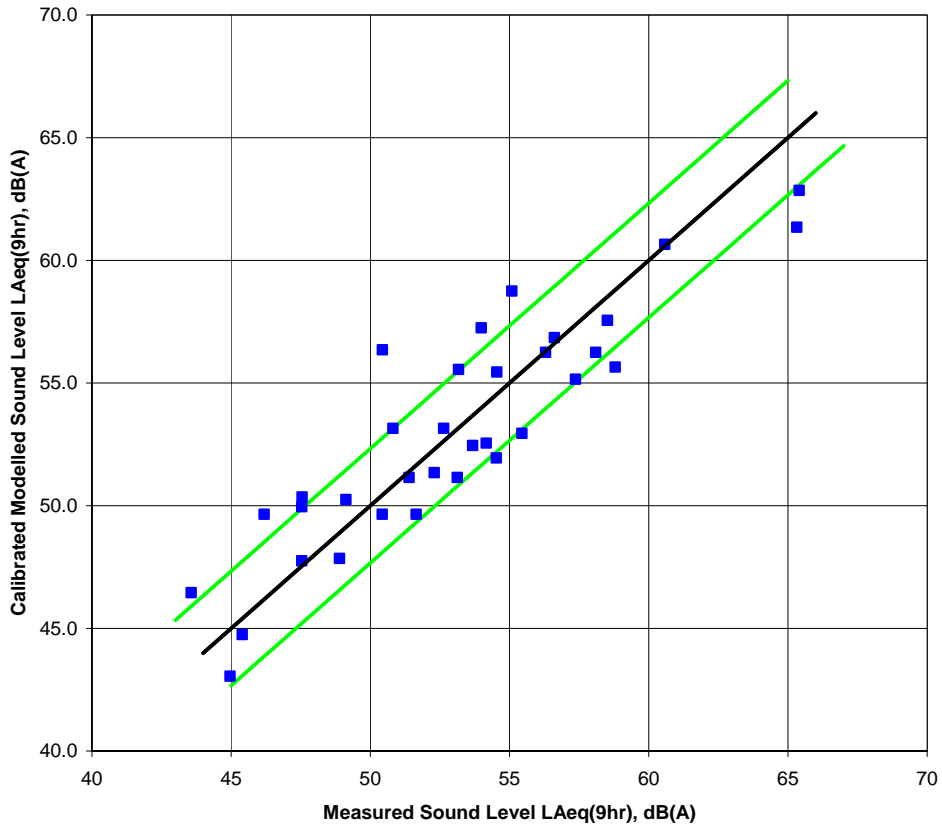


Figure 1 graphically presents the measured versus calibrated noise levels after the noise model is calibrated using the mean validation difference determined from the results presented in Table 13. These are shown as ‘blue’ points in the graph. Figure 1 shows that the measured with calibrated modelled results correlate well and most points lie within the range of one standard deviation (‘green’ curves) from the mean curve (centre ‘black’ curve).

9.2 Post-Construction Traffic Noise Assessment

9.2.1 Single Point Receivers

After calibrating the design noise model using the post-construction validation differences applicable to each location (determined from Table 13 of this report), the re-forecast 2017 traffic data was then used to model 2017 traffic noise levels, which are used in this post-construction noise assessment.

To assess the 2017 modelled traffic noise levels for this post-construction noise assessment, the modelled 2017 traffic noise levels are compared to:

- the EIA's noise criteria,
- the EIA's 2016 noise predictions, and
- the ONMR's 2016 design noise levels.

It is noted that alongside the edges of the main carriageways of the Upgrade there is profile-line-markings that generate noise when vehicles pass over them. A study into the noise effects of vehicles passing over the profiled-line-markings was conducted and the findings of this study are presented in **Appendix D** of this report. The findings of the study indicate that although noise pertaining to vehicles passing over profile-line-markings has a distinct character that is clearly audible and identifiable, its effects on overall project noise levels are likely to cause increases of up to 2.2dB(A) and typically less than 1dB(A) in the L_{Aeq} scale.

Given that the RTA intends to have the profile-line-markings removed, a conservatively small adjustment of -0.5dB(A) is applied to the 2017 modelled noise levels presented herein to account for the likely contribution that profile-line-marking noise events would have on post-construction traffic noise levels.

Table 14 presents these results at each noise sensitive receiver as presented in Table E.1 of the ONMR. The noise levels presented in the table are rounded to the nearest decibel values, as per the requirements of the ENMM, except for noise levels extracted from the EIA which are presented as they appear in the EIA and differences between noise levels which are presented to the nearest one decimal point value.

Table 14 – Assessment of 2017 Post Construction Noise Levels against the EIA’s Noise Criteria, the EIA’s 2016 Noise Predictions and the ONMR’s 2016 Designed Noise Levels, dB(A)

NCA & ID	Address	Receiver Location	EIA Noise Criteria L _{Aeq} (9hr) ^{1,2}	EIA Predicted 2016 L _{Aeq} (9hr) Noise Levels ⁴	Design Stage Predicted 2016 L _{Aeq} (9hr) Noise Levels (2016 D)	Post Construction Modelled 2017 L _{Aeq} (9hr) Noise Levels (2017 A)	Variance V = 2017 A – 2016 D	V ≤ 2dB(A)?	Complies with EIA Noise Criteria?	Assessment & Acoustic Treatment Comments
1a	Lot 264 Bayside Way	1.5m above Ground Level	55	52	55	50	-5.0	Yes	Yes	–
1b	2 Cudgen Street	1.5m above Ground Level	55	48	50	47	-3.2	Yes	Yes	–
2	Bashforth's Lane	1.5m above Ground Level	55	54.5	63*	59	-4.5	Yes	No	Acoustically Treated ³
3a	Ferry Reserve Caravan Park (Amenities Block)	1.5m above Ground Level	65	58	59	56	-2.3	Yes	Yes	–
3b	Ferry Reserve CP (Camp)	1.5m above Ground Level	63	-	57	55	-2.0	Yes	Yes	–
3c	Riverside Crescent	1.5m above Ground Level	55	54	53	52	-1.3	Yes	Yes	–
4a	2 Rajah Road	1.5m above Ground Level	60.5	61*	55	54	-1.0	Yes	Yes	Acoustically Treated ³
4a	2 Rajah Road	Top floor	60.5	61*	59	58	-0.9	Yes	Yes	Acoustically Treated ³
4b	1 Rajah Road	1.5m above Ground Level	61	61*	61*	60*	-1.2	Yes	Yes	Acoustically Treated ³
4b	1 Rajah Road	1.5m above Ground Floor	61	-	63*	62*	-1.2	Yes	No	Acoustically Treated ³
4c	2 Arika Avenue	1.5m above Ground Level	61	59	68*	65*	-3.0	Yes	No	Acoustically Treated ³
4c	2 Arika Avenue	Top floor	63	63*	70*	68*	-1.7	Yes	No	Acoustically Treated ³
4d	3 Arika Avenue	1.5m above 1st Floor Level	65	-	63*	61*	-1.6	Yes	Yes	Acoustically Treated ³
4e	5 Arika Avenue	1.5m above Ground Floor	64	58	65*	60*	-4.4	Yes	Yes	Acoustically Treated ³
4f	7 Arika Avenue	1.5m above Ground Floor	69	-	68*	66*	-1.7	Yes	Yes	Acoustically Treated ³
5a	1 Oola Place	1.5m above 1st Floor Level	62.5	-	65*	63*	-1.3	Yes	No	Acoustically Treated ³
5a	1 Oola Place	1.5m above Ground Level	62.5	56	64*	63*	-0.6	Yes	Yes	Acoustically Treated ³
5b	2 Oola Place	1.5m above 1st Floor Level	62.5	-	64*	61*	-2.6	Yes	Yes	Acoustically Treated ³

NCA & ID	Address	Receiver Location	EIA Noise Criteria L _{Aeq} (9hr) ^{1,2}	EIA Predicted 2016 L _{Aeq} (9hr) Noise Levels ⁴	Design Stage Predicted 2016 L _{Aeq} (9hr) Noise Levels (2016 D)	Post Construction Modelled 2017 L _{Aeq} (9hr) Noise Levels (2017 A)	Variance V = 2017 A – 2016 D	V ≤ 2dB(A)?	Complies with EIA Noise Criteria?	Assessment & Acoustic Treatment Comments
5c	3 Oola Place	1.5m above 1st Floor Level	62	-	58	55	-2.7	Yes	Yes	Acoustically Treated ³
5d	1 Oba Place	1.5m above 1st Floor Level	64	-	63*	61*	-2.6	Yes	Yes	Acoustically Treated ³
5d	1 Oba Place	1.5m above Ground Level	62	-	61*	58	-2.6	Yes	Yes	Acoustically Treated ³
5e	2 Oba Place	1.5m above 1st Floor Level	64.5	61.5*	69*	65*	-4.1	Yes	No	Acoustically Treated ³
5f	19 Weeronga Way	1.5m above Ground Floor	62	-	60*	58	-2.6	Yes	Yes	Acoustically Treated ³
5f	19 Weeronga Way	1.5m from Ground Level	60	-	59	57	-2.8	Yes	Yes	Acoustically Treated ³
5g	23 Weeronga Way	1.5m above Ground Floor	64.5	58.5	64*	62*	-2.2	Yes	Yes	Acoustically Treated ³
5g	23 Weeronga Way	1.5m from Ground Level	66	-	59	62*	-2.1	Yes	Yes	Acoustically Treated ³
6	5 Weeronga Way	1.5m above Ground Floor	55	-	54	52	-2.0	Yes	Yes	-
6	5 Weeronga Way	1.5m above Ground Level	55	48	54	52	-2.0	Yes	Yes	-
7a	1 Tongarra Drive	1.5m above Ground Level	61	-	66*	63*	-2.9	Yes	No	Acoustically Treated ³
7b	5 Tongarra Drive	1.5m above Ground Level	67	63*	64*	61*	-3.1	Yes	Yes	Acoustically Treated ³
7b	5 Tongarra Drive	1.5m above Ground Floor	67	-	63*	61*	-2.3	Yes	Yes	Acoustically Treated ³
7c	11 Tongarra Drive	1.5m above Ground Floor	74	-	68*	66*	-2.6	Yes	Yes	Acoustically Treated ³
7d	50 Tongarra Drive	1.5m above Ground Floor	67	-	58	56	-2.1	Yes	Yes	-
8	24 Binya Place	1.5m above Ground Level	50	39.5	47	45	-1.8	Yes	Yes	-
9a	19 Mountain View Road	1.5m above Ground Level	55	57	55	53	-2.0	Yes	Yes	-
9b	'Garema' Coolamon Scenic Drive	1.5m above Ground Level	56	56.5	59	57	-1.6	Yes	No	Acoustically Treated ³
10a	Yamble Drive South	1.5m above Ground Level	70.5	63*	64*	61*	-3.1	Yes	Yes	Noise reduction benefit of 9dB(A) from project. Acoustic Treatment Offered / Provided ³ where acute

NCA & ID	Address	Receiver Location	EIA Noise Criteria L _{Aeq} (9hr) ^{1,2}	EIA Predicted 2016 L _{Aeq} (9hr) Noise Levels ⁴	Design Stage Predicted 2016 L _{Aeq} (9hr) Noise Levels (2016 D)	Post Construction Modelled 2017 L _{Aeq} (9hr) Noise Levels (2017 A)	Variance V = 2017 A – 2016 D	V ≤ 2dB(A)?	Complies with EIA Noise Criteria?	Assessment & Acoustic Treatment Comments
10b	60 Yamble Drive	1.5m above Ground Floor	70	-	62*	58	-3.3	Yes	Yes	Acoustically Treated ³
10b	60 Yamble Drive	1.5m above Ground Level	67	-	60*	57	-3.2	Yes	Yes	Acoustically Treated ³
10c	48 Yamble Drive	1.5m above Ground Level	60.5	59	60*	59	-1.0	Yes	Yes	-
11a	10-14 Balemo Drive South	1.5m above Ground Level	60.5	56.5	55	55	0.3	Yes	Yes	-
11b	Balemo Drive South (Motel)	1.5m above Ground Level	61	-	56	57	0.7	Yes	Yes	-
11c	1 Kulgung Court	1.5m above Ground Level	61	54	54	55	1.1	Yes	Yes	-
12a	Prokop residence, The Tunnel Road	1.5m above Ground Level	55	-	54	49	-4.9	Yes	Yes	-
12b	Taylor residence, Lot 6 Tunnel Road	1.5m above Ground Level	50	52	56	51	-4.8	Yes	Yes	Acoustically Treated ³
12c	Burton residence, The Tunnel Road	1.5m above Ground Level	56	-	60*	56	-4.1	Yes	Yes	-
13	Nearest residence - Ulpira/ Nargoan Court	1.5m above Ground Level	60.5	48.5	53	53	0.6	Yes	Yes	-
14	Aloota Crescent	1.5m above Ground Level	54	-	48	49	1.1	Yes	Yes	-
15	Matong Drive	1.5m above Ground Level	64.5	58	59	59	0.4	Yes	Yes	-
16a	Humble Pie Company	1.5m above Ground Level	-	63.5*	65*	66*	1.4	Yes	Yes	Commercial premises
16b	Christian Life Centre	1.5m above Ground Level	69.5	69*	70*	72*	1.4	Yes	No	Acoustically Treated ³
16c	Funeral Parlour	1.5m above 1st Floor Level	64	-	69*	70*	0.6	Yes	No	Acoustically Treated ³
16c	Funeral Parlour	1.5m above Ground Level	64	63.5*	68*	66*	-1.8	Yes	No	Acoustically Treated ³
17a	19 Gilba Avenue	1.5m above Ground Level	60	-	59	55	-4.5	Yes	Yes	Acoustically Treated ³
17b	21 Gilba Avenue	1.5m above Ground Level	59	59.5	56	52	-4.4	Yes	Yes	Acoustically Treated ³
18a	121 Balemo Drive	1.5m above 1st Floor Level	64	-	60*	57	-3.3	Yes	Yes	Acoustically Treated ³

NCA & ID	Address	Receiver Location	EIA Noise Criteria L _{Aeq} (9hr) ^{1,2}	EIA Predicted 2016 L _{Aeq} (9hr) Noise Levels ⁴	Design Stage Predicted 2016 L _{Aeq} (9hr) Noise Levels (2016 D)	Post Construction Modelled 2017 L _{Aeq} (9hr) Noise Levels (2017 A)	Variance V = 2017 A – 2016 D	V ≤ 2dB(A)?	Complies with EIA Noise Criteria?	Assessment & Acoustic Treatment Comments
18b	123 Balemo Drive	1.5m above 1st Floor Level	60.5	-	58	55	-3.4	Yes	Yes	Acoustically Treated ³
18b	123 Balemo Drive	1.5m above Ground Level	60.5	61*	56	53	-3.4	Yes	Yes	Acoustically Treated ³
19a	Lot 1 Pacific Highway	1.5m above Ground Level	59	59	54	56	2.2	No	No	Acoustically Treated ³
19b	170 Billinudgel Road	1.5m above Ground Level	60	-	63*	65*	2.1	No	No	Acoustically Treated ³
19c	171 Billinudgel Road	1.5m above Ground Level	55	-	62*	62*	0.1	Yes	No	Acoustically Treated ³
19d	175 Billinudgel Road	1.5m above Ground Level	58.5	59	66*	67*	0.8	Yes	No	Acoustically Treated ³
19e	Holm res. Billinudgel Road	1.5m above Ground Level	50	52.5	59	56	-2.1	Yes	No	Acoustically Treated ³
20a	Holm farm Billinudgel Road	1.5m above Ground Level	50	46	50	47	-2.9	Yes	Yes	-
20b	Lot 4 (22) Stock Route Road	1.5m above Ground Level	55	-	63*	61*	-2.6	Yes	No	Acoustic Treatment Offered
20c	Lot 3 Stock Route Road	1.5m above Ground Level	50	-	55	53	-2.5	Yes	No	Acoustically Treated ³
20d	Lot 4 (24) Stock Route Road	1.5m above Ground Level	50	-	55	52	-2.9	Yes	No	Acoustically Treated ³
21	Jagwen Billinudgel Road	1.5m above Ground Level	51	50.5	58	57	-0.1	Yes	No	Acoustically Treated ³

Notes: 1. ECRTN 'Base' or 'Allowance' criteria established in EIA (2002)

2. ECRTN 'Base' or 'Allowance' criteria determined from modelled 2002 noise levels presented in EIA (2002)

3. Architectural treatment already provided by RTA. Architectural treatment provided prior to the commencement of construction and was based on the EIA (2002) predicted 2016 noise levels

4. Predicted 2016 L_{Aeq}(9hr) traffic noise levels presented in EIA (2002)

* Acute noise levels, exceeding L_{Aeq}(9hr) 60dB(A)

In summary, Table 14 shows that for the majority of the assessment locations, the 2017 post-construction noise levels comply with the EIA noise criteria. Where exceedances are found, the properties have already been architecturally treated by the RTA.

The variance (V) between the 2017 post-construction noise levels and the 2016 design noise levels fall within the acceptable 'less than or equal to 2dB(A)' objective at all residential properties as per the requirements of the ENMM, with the only exceptions being the following residences which have variances slightly greater than 2dB(A) [ie 2.1 – 2.2dB(A)]:

- Lot 1 Pacific Highway - the post-construction 2017 noise level is lower than the EIA predicted 2016 noise level and this residence has been architecturally treated by the RTA
- 170 Billinudgel Road - this residence has been architecturally treated by the RTA

In accordance with Practice Note VIII of the ENMM, and as part of the post-construction noise assessment, for all locations where the "Variance" is positive (+ve), the noise data has been examined, the prediction methodology and model has been reviewed, and the reasons for differences in the "Variance" values have been found to be due to the re-forecast 2017 traffic volumes in most cases being greater than the 2016 design volumes and limitations associated with using topographic data of 2m resolution to model what is in the field. Therefore, the post-construction 2017 noise model shows a clear trend of falling within the acceptable margin of 2dB(A) for noise prediction modelling as per Practice Note VIII of ENMM and there is a clear trend in the traffic noise levels which are lower than the predictions made..

Table 14 also shows that at some locations the post-construction modelled 2017 noise levels are different to the predicted 2016 noise levels presented in the EIA. Upon review of both noise models the following discrepancies have been found which could cumulatively have caused these differences:

- Higher volumes of light vehicles used in the design noise model [SWTC 2016] and in the post-construction noise assessment model [re-forecast 2017], compared to the volumes used in the EIA noise model
- Higher volumes of heavy vehicles used in the design noise model [SWTC 2016] and in the post-construction noise assessment model [re-forecast 2017], compared to the volumes used in the EIA noise model
- Slightly higher traffic speeds used in the post-construction noise assessment model (2017) for the Upgrade and the Brunswick Valley Way, compared to the speeds used in the EIA noise model
- More detailed input survey data, road alignment geometry and building data details used in the detail design noise model of the Project in comparison to the EIA noise model
- Differences in road pavement corrections applied to the noise models

- Variations in the exact modelling receiver positions (horizontally and vertically) used in the EIA versus those used in the design noise model
- The Upgrade caused different façades at the same addresses, in some cases, to be worst-affected than prior to the Upgrade, which alters the noise monitoring location and subsequently the calibration factors applied to that new location for the post-construction noise assessment
- Addition of calibration factors and additional confidence interval factors in the design noise model (see ONMR), which causes conservatively higher output noise levels than the EIA noise model, but provides for a more conservative assessment and design
- Different noise modelling software package used for the EIA noise model (ENM software) compared to the detail design and post-construction noise assessment model (SoundPLAN software)
- Slight increases in traffic from 2016 to 2017.

Notwithstanding the above, although at some assessment locations differences between the EIA's modelled 2016 noise levels and the post-construction modelled 2017 noise levels are significant, where this occurs the properties have been architecturally treated by the RTA. Furthermore, in all cases where differences are noted, the level of architectural treatment applied adequately addresses those differences.

Also, where properties are modelled to have 'acute' noise levels in 2017, architectural treatment has already been applied or offered by the RTA.

9.2.2 Noise Contours

Using the calculated VDmean from Table 13 of this report and the Project's noise model, night time $L_{Aeq(9hr)}$ noise contours were generated for the year 2017. These noise contours were then compared to the night-time $L_{Aeq(9hr)}$ noise contour lines identified in Figures 20.9 and 20.10 in Appendix 20 of the SWTC. This comparison is presented in **Appendix B** and indicates that the noise contours based on the validated model are generally within the noise contour lines of the SWTC. Furthermore, when compared to the design contours presented in Figure D8 of the ONMR, the validated model contours are generally within the design contours. Where there are exceptions, these are not adjacent to noise sensitive receivers.

It is noted that noise contours are generated within the noise model based on an interpolation from a series of calculations to specific points within a regularly spaced grid, 1.5 m above ground level. Therefore, the noise contours are estimates of the predicted noise levels, and that contour values may differ slightly from equivalent single point receiver calculations.

9.2.3 Adequacy of Noise Mitigation Measures

By analysis of the post-construction single point receiver noise levels and the post-construction noise contours produced herein, it can be seen that areas that have had in-corridor and road-

side noise mitigation measures implemented, tend to have lower traffic noise levels than at untreated areas.

Further to the above, Chapter 9.2.1 of this report presents results which confirm compliance with the design objectives. Also Chapter 9.2.2 and **Appendix B** of this report, confirms that the post-construction noise contours are generally within the noise contour lines of the SWTC and within the design contours presented in Figure D8 of the ONMR.

This confirms that there is a clear trend of compliance (ie. a clear trend in traffic noise levels which are lower than the predictions made), which confirms the adequacy of the traffic noise mitigation measures applied to this Project.

9.2.4 Passive Recreational Areas

Of the three passive recreation areas in the vicinity of the Upgrade, Brunswick Heads Nature Reserve is considered the worst-affected followed by the Billinudgel Nature Reserve.

Brunswick Heads Nature Reserve, comprising five areas, has its large area located adjacent to the bridge (Pocket B identified in the ONMR) and the large area to the south of the Brunswick Heads North Interchange, between the alignment and Brunswick Heads township (Pocket A identified in the ONMR), are partially affected by traffic noise.

Modelling during the design stage indicated that noise levels at these reserves prior to the Upgrade partially exceeded the noise criteria for passive recreation areas of $L_{Aeq(15hr)}$ 55 dB(A) as set out in the ECRTN.

At Pocket A, the southern area of the Brunswick Heads Nature Reserve, non-compliance with the criteria occurred for approximately 15% of the total area before the Upgrade. At Pocket B of the Brunswick Heads Nature Reserve along the river, pre-Upgrade traffic noise levels exceeded the criteria for approximately 21% of the total area.

Similarly, at the Billinudgel Nature Reserve, pre-Upgrade traffic noise levels exceeded the criteria for approximately 2% of the total area.

Post-construction noise modelling indicates that noise levels at both Pockets A and B of the Brunswick Heads Nature Reserve would insignificantly increase as a result of the Project. Furthermore, use of the nature reserve in the non-compliant areas of Pocket B consists of a vehicle track and inaccessible wetlands.

At the Billinudgel Nature Reserve, the Project has shifted the traffic route west, resulting in a reduction in road traffic noise across the reserve.

9.3 L_{Amax} Noise Monitoring Outcomes

9.3.1 L_{Amax} Noise Levels from the Upgrade

The EIS and EIA presented predicted L_{Amax} noise levels at certain receiver locations, based on theoretical maximum noise levels of heavy vehicles obtained from Australian Design Rule

28/01. The post-construction monitored L_{Amax} noise levels are compared to the pre-construction monitored L_{Amax} noise levels for the purpose of evaluating the potential differences that may have occurred as a result of the Upgrade.

The EIS and EIA state:

'The measurement results detailed in Appendix A and in the original EIS at those residences closest to the existing highway indicate the typical maximum levels (LA1) are approximately 70-75dBA'.

An evaluation of the maximum noise levels measured at the long-term noise monitoring locations was conducted and typical maximum traffic noise levels were found to be between 70-75dB(A), which indicates similar maximum noise levels to those measured for the EIA and EIA pre-construction of the Upgrade.

A comparison was also made of the L_{Amax} noise levels measured post-construction with the noise monitoring undertaken by Renzo Tonin & Associates in 2005 (pre-construction, presented in the ONMR), and a significant reduction in typical L_{Amax} noise levels was noted for some residences which benefited from the Upgrade, whilst similar levels were found for the remaining residences. That is, out of all of the NCAs analysed, approximately 80% of the NCAs show L_{Amax} noise levels either do not increase significantly or reduce as a result of the Upgrade, and for the remaining NCAs where increases were predicted, the RTA has architecturally treated those dwellings.

Furthermore, an analysis was also conducted of the post-construction long-term noise monitoring results to evaluate typical differences between L_{Amax} and $L_{Aeq(1hr)}$ noise levels, in accordance with Practice Note III of the ENMM. The typical differences measured at the monitoring locations ranged from 14 to 17dB(A), with the average difference being at 15dB(A). This existing difference between these two noise metrics will reduce over time as stated in the EIA, "*The increased traffic numbers in the future would cause an increase in the night time noise levels ($L_{Aeq,9hr}$) and consequently the differences between the $L_{Aeq,9hr}$ and the maximum noise events would reduce over time*". Therefore, it is forecasted that by 2017 the L_{Amax} to L_{Aeq} differential would reduce to well below the 15dB(A) guideline for assessing a maximum noise event.

For a more detailed analysis, to determine L_{Amax} noise levels and events throughout the night time period (10.00pm to 7.00am) additional measurements were conducted using long-term unattended loggers measuring noise levels at one second intervals at three selected locations. Results of the L_{Amax} measurements are presented in Table 14 below. The comparison with 2005 monitored L_{Amax} noise levels is also presented.

Table 15 – Summary of Maximum Noise Levels and Events, dB(A)

Address	Distance to Old Pacific Hwy	Distance to Upgrade	L _{Amax} (10pm – 7am)		No. Events (10pm – 7am)	
			Design Stage (2005)	Post Opening (2007)	Design Stage (2005)	Post Opening (2007)
4/1 Rajah Rd	50	70	77-82	68-77	11	22
50 Tongarra Dr	30	80	79-88	69-76	37	63
48 Yamble Dr	50	100	77-84	71-77	40	50

From the above table it can be seen that L_{Amax} noise levels have reduced since those measured during the 2005 design stage. The main reason being that the Upgrade has resulted in the L_{Amax} noise source (ie. heavy vehicles) being further away from the monitoring locations.

It is noted that this post-construction analysis includes the noise of vehicles passing over the 'profiled-line-marking' alongside the edges of the main carriageways, which may have contributed to the number of L_{Amax} noise events. A short study into the effects of vehicles passing over the profiled-line-markings was conducted and the findings of this study are presented in **Appendix D** of this report. The study found that there was no increase in the measured L_{Amax} noise levels, in terms of noise amplitude alone, however it is likely that profile line marking events would cause an increase in the number of L_{Amax} noise events. Notwithstanding the above, it is anticipated that the profile line markings will be removed and subsequently the frequency of occurrence of L_{Amax} noise events is expected to be reduced.

9.3.2 L_{Amax} Noise Levels from Yelgun Rest Area

Short term attended measurements of the Yelgun Rest Area was conducted at the monitoring locations (LM4, LM5 and LM6) presented in Table 14 above. Measurements were conducted between 11.00pm and 1.30am on Monday 3rd December 2007. The results from the L_{Amax} monitoring are presented in Table 16 below.

Table 16 – Assessment of Measured L_{Amax} Noise Levels from Yelgun Rest Area, dB(A)

Address	REF L _{Amax} Noise Criteria	REF Predicted L _{Amax} Noise Levels	Measured L _{Amax} Noise Level (during measurements)	No. of Events Measured During the Survey Period
Holm Farm, 157 Billinudgel Rd	49	-	Inaudible & Immeasurable	
Jagwen, Billinudgel Rd (RTA owned)	54	58	55-69	17
Lot 4 (22) Stock Route Rd	49	41	Inaudible & Immeasurable	

During the measurements at Holm Farm and the property at Lot 4 (22) Stock Route Road it was noted that activity from the rest area was inaudible and immeasurable. L_{Amax} noise levels measured at the Jagwen property were exceeding the REF noise criteria, however the results were found to be reasonably similar to the levels predicted in the REF and those predicted at

the project design stage in the ONMR. Notwithstanding the above, it is noted that this property has already been architecturally treated by the RTA.

10 CONCLUSION

Renzo Tonin & Associates (NSW) Pty Ltd has completed the post-construction operational noise monitoring and assessment of road traffic noise for the Pacific Highway Upgrade, Brunswick Heads to Yelgun, NSW (the Project) in accordance with the requirements of MCoA No.34.

The design noise model was found to be within an acceptable margin of 2dB(A) for noise prediction modelling as per Practice Note VIII of the ENMM at all assessment locations, and the 2017 post-construction noise levels comply with the EIA noise criteria, with the exception of a few residences which have already been acoustically treated by the Roads and Traffic Authority. This confirms that the design noise model has achieved an acceptable level of accuracy and confirms the adequacy of the traffic noise mitigation measures implemented on this Project.

Noise contours produced for the design year were compared to the noise contour lines identified in the SWTC, and indicate that the noise contours based on the validated noise model are generally within the noise contour lines of the SWTC. Furthermore, when these post-construction generated noise contours are compared to the design contours presented in the ONMR, they are shown to generally fall within the design noise contours, confirming an overall acceptable level of accuracy achieved with the design noise model and the adequacy of the traffic noise mitigation measures implemented on this Project.

In summary:

- the post-construction operational noise assessment of traffic noise levels confirm that the intended acoustical outcomes as described in the environmental documents were achieved,
- there is a clear trend in the post construction noise levels being lower than the predictions made,
- the post-construction operational noise assessment found there to be no clear trend of shortfalls in the design outcomes, therefore no additional noise mitigation measures are necessary,
- the implemented traffic noise mitigation measures were evaluated and as a result of a clear trend of noise compliance being demonstrated, this confirms the adequacy of the traffic noise measures implemented on this Project, and
- community noise complaints have been addressed by re-assessing traffic noise levels at complainant properties or properties in the vicinity of where complaints have arisen, and noise levels were found to comply with the applicable environmental noise objectives.